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WAVE-LENGTHS OF THE CHROMOSPHERE FROM SPECTRA OBTAINED AT THE 1905 ECLIPSE[1]

By S. A. MITCHELL

The spectra with which the present paper deals were obtained on August 30, 1905, while the writer was a member of the United States Naval Observatory eclipse expedition. A special service squadron under command of Rear-Admiral Colby M. Chester, U.S.N. (then superintendent of the Naval Observatory), carried the party and their equipment across the Atlantic. Three separate stations were occupied; one at Guelma in Algeria, the other two in Spain. Of the two in Spain, one was located near the edge of the shadow-path at Poerti Coeli, the other near the central line of totality at the little town of Daroca. A preliminary account of the results obtained by the various parties has been published.[2]

The party at Daroca was under the general supervision of Professor W. S. Eichelberger, and the instrumental equipment was as follows: Forty-foot horizontal camera under the direction of Mr. L. G. Hoxton; time-service and longitude determination under the direction of Mr. Everett I. Yowell; various electrical and meteorological instruments under the direction of Professor F. H. Bigelow, U.S. Weather Bureau; and several spectroscopic instruments under the charge of the writer. The above-mentioned and Mr. C. P. Olivier were assisted in the erection and adjustment of the

[1] Printed in advance of the Naval Observatory report by permission from the Superintendent of the Naval Observatory.

[2] See C. M. Chester, *Astrophysical Journal*, **23**, 128, 1906.

various instruments by the chief carpenter, the chief machinist, and four sailors from the U.S.S. "Minneapolis." About six weeks were spent in Daroca in preparation.

On the trip across the Atlantic, the officers and men of the "Minneapolis" were interested in the astronomical work by conferences and lectures. Five days before the day of the eclipse, the original party in Daroca was augmented by the arrival of officers and men from the ship, to the number of twenty-five. Officers were placed in charge of instruments with sailors to assist them. Frequent drills were held, and so thoroughly efficient was the service that everything passed off on eclipse day without a hitch.

As determined by Mr. Yowell, the position of Daroca was: longitude $= 0^h 5^m 40^s.31$ W.; latitude $= 41^\circ 6' 29''.4$. For the determination of longitude, time signals were exchanged with the observatory of Madrid, a telegraph line being run to the eclipse camp, and the efficient services of the operator at Daroca, Señor Garcia, being freely put at the disposal of the eclipse observers.

The eclipses of 1900 and 1901 showed the efficiency of gratings, both plane and concave, for spectroscopic work. There are many advantages of gratings over prisms, chief of which may be mentioned (1) normal spectrum, (2) increased dispersion. For eclipse work, a slit is unnecessary, and used as an objective instrument, the amount of the astigmatism is a negligible quantity.

The spectrographic equipment consisted of five instruments, three of small dispersion and two of larger dispersion. The present paper will deal only with the large instruments. One of these was a plane grating, the other a concave grating.

PARABOLIC GRATING

This grating belongs to the Rumford Committee and was kindly loaned by Professor F. A. Saunders of Syracuse University. Instead of being ruled on a spherical concave surface, it was ruled on a parabolic surface. The grating was four inches in diameter, and had 14,438 lines to the inch. According to Mr. L. E. Jewell, its spectra were as brilliant as ordinarily obtained from a 6-inch grating, and its definition was equal to any Rowland grating he had ever seen.

The mounting of the grating was exceedingly simple. Light from the coelostat mirror was reflected horizontally to the grating and from there reflected and brought to a focus on the photographic plate. Grating and photographic plate were inclosed in a light-tight mahogany box. Exposures were made by a convenient flap shutter placed in the beam of light from the coelostat. If the photographic plate is perpendicular to the grating normal (and, consequently, parallel to the grating), the spectrum is normal.

The grating had a focal length of 5 feet (150 cm), corresponding to 10-foot radius of curvature in a concave grating. For focus, it was necessary to bend the plates to a radius of $2\frac{1}{2}$ feet (75 cm). It was, therefore, manifestly impossible to use glass plates, and the emulsion was coated on heavy gelatine films which were $1\frac{1}{4}\times 12$ inches (3×30 cm). Two plate-holders were used each holding six parallel strips. By repeated practice, it was possible in a fraction of a second to drop the plate-holder from one film to the next.

This instrument was focused by a collimator arranged by Mr. Jewell for the 1901 eclipse, and slightly altered as the result of experience gained in Sumatra. This collimator consisted essentially of two concave mirrors and a slit, so that by its means a parallel beam of light could be obtained from a slit-source. The collimator was first focused by a 5-inch visual telescope.

PLANE GRATING

To supplement the work of the parabolic grating, and particularly to gain information about the red end of the spectrum, a flat grating was used. This was a Rowland 6-inch grating belonging to the Naval Observatory. It had 15,000 lines per inch, with ruled lines $3\frac{1}{2}$ inches long. This grating was used by the writer in Sumatra in 1901. The definition was excellent.

Light from the coelostat mirror was reflected horizontally and fell on the grating. After reflection, the light was brought to a focus on the photographic plate by a Clark 5-inch visual lens of 72 (184 cm) inches focus. Grating, lens, and plate were inclosed in a light-tight mahogany box, and exposures were made, as with the parabolic grating, by a flap shutter. The spectra were brought to a focus almost in a plane, and it was therefore possible to use glass

plates, which were $1\frac{1}{2} \times 12$ inches (4×30 cm). Six plates were placed in parallel strips in each of two plate-holders. As with the parabolic grating, if grating and plate are each perpendicular to the line joining them, the spectrum is normal. Each of the boxes holding plane and parabolic gratings was inclined to the vertical in order to bring the line joining the sun's cusps approximately perpendicular to the length of the plate. As Daroca was not exactly on the central line of totality, a compromise was made for the positions at second and third contacts.

METHODS OF OBSERVING

Eclipse day, August 30, opened very auspiciously. First contact was observed under clear skies, but soon after, clouds had gathered. Five minutes before second contact, a large cloud obscured the sun, but it passed off before totality, and an uninterrupted view of the total phase was obtained. The citizens of Daroca gathered in great numbers, as closely as they could come to the eclipse camp. During the progress of the partial phase, each Spaniard present seemed bent on telling to his neighbor in a loud tone of voice the full details of what he knew about the subject. The noise of their conversation increased with the progress of the eclipse, and totality was greeted with such a shout that it was impossible to hear the counted seconds which should serve as guides to the exposures.

The plan had been for the writer to observe the disappearing crescent of the sun through a binocular, over one-half of which was arranged a plane mirror and plane grating combination, adjusted in such a way that with one eye through the binocular the crescent sun could be seen, with the other, its spectrum in the green region. This worked perfectly, and the word "Go" from him gave notice to the person counting seconds to restart his count. Two unlooked-for features were encountered: one being that the conversation of the Spaniards was rather loud, the second that the total phase occurred some ten seconds or more before it was expected.

It was planned to catch the "flash spectrum" with both instruments at the beginning and end of totality, to give two short exposures just before the first flash and, just after the second flash, one

long exposure at mid-totality, and others of varying length between. As above stated, each instrument had twelve plates. The program for each instrument was carried out practically as arranged.

THE DETERMINATION OF FOCUS

1. *Parabolic grating.*—This instrument was in the capable hands of Lieutenant Alfred G. Howe, U.S.N., who was assisted by two sailors from the "Minneapolis." Mr. Howe opened the shutter and made the exposures, one of the sailors shifted the plate-holder between exposures. the other sailor was stationed near the coelostat for the purpose of rendering assistance if any emergency arose. His help was not needed. The writer wishes to express to Mr. Howe his deep gratitude for the thoroughly efficient manner in which he handled the instrument.

This instrument was focused three days before the eclipse by the writer with the use of the collimator. It was, of course, possible to focus only in the visible region, a fluorescent eyepiece not being on hand. It was felt that the seasoned mahogany box, which held grating and photographical plate, could be fairly relied upon not to warp in the interval. In addition, the collimator was needed at the other Spanish station to focus its grating. No attempt was made to focus on stars, and it was felt to be unwise to leave the important operation of obtaining focus to the few hurried minutes just before totality while the cusps of the sun could be seen. The accuracy of focus will be seen from the photographs which are herewith reproduced. The flash spectrum is shown from λ 3300 to the D_3 line of helium. The focus at the violet end is hardly as sharp as it is from λ 4000 to the red end. The accuracy of the wave-length determinations speak louder than can any words concerning the sharpness of the spectra.

2. *Plane grating.*—On eclipse day, this instrument was handled by the writer with the help of two sailors who assisted as did the others for the parabolic instrument. An unfortunate accident occurred on the morning of the eclipse. The chief carpenter was requested to make two wooden braces to prop up the box and incline it at the proper angle to the vertical. (From the position of the box, it was more convenient to adjust for focus with the box

horizontal.) Through a misunderstanding, the carpenter nailed the braces to the box in the absence of the writer with the result that the focus was disturbed. Fortunately, however, the parts of the spectra in best focus are the red ends, though the focus is not as good as for the parabolic grating. Nevertheless the spectra were well measurable at this end and these are used to supplement the parabolic grating measures. On one of the spectra with the flat grating, the C-line (λ 6563) is seen.

SPECTRA

The photographs were developed in the dark room of the College of Daroca where running water was obtained. The writer wishes to express his thanks to Padre Felix Alvirez, the president of the college, for his many kindnesses. As the running water became rather warm in the daytime, it was necessary to develop at night. At 5:00 o'clock on the morning following the eclipse, the spectra were hung up to dry.

As above stated, the films for the parabolic grating were coated on heavy celluloid; for the flat grating, on glass. Lumière Panchromatic C was the emulsion used for the six films in the first plate-holder at beginning of totality, while Seed's Orthochromatic was used in the second plate-holder. For the plane grating instrument, Lumière Panchromatic C and Cramer Trichromatic were used in the two plate-holders respectively.

Results showed that the Lumière emulsion did not give the sensitiveness that had been expected from tests made before leaving home, so that the second plate-holder for each instrument gives more detail than the first in each case.

As the present paper is for the purpose of giving for the flash spectrum wave-lengths, intensities, etc., with as great an accuracy as possible, only one photograph with each instrument was measured. Those selected were the flash spectrum for each instrument at the end of totality. A future paper will deal with the spectra of chromosphere, corona, etc., which are given by the remainder of the plates.

The distinguishing features of the present spectra are (1) their good definition, (2) their normal dispersion, and (3) their extent,

from λ 3300 to D_3 for parabolic grating, and to λ 6200 for plane grating. The flash spectrum from the parabolic grating is shown in Plate XIV, *a*. In order to reproduce it on nearly the original scale much of the ultra-violet is omitted. This is reproduced as a positive when the lines are *bright*. For a more ready comparison with Rowland, the enlargements are negatives. It will be noticed at once from original and from enlargements that the continuous spectrum at the middle of the arcs was quite strong. Running down the center of this continuous spectrum is a small strip where the continuous spectrum is not so strong. This may be best seen in the green and orange regions. On the enlargements, particularly at the violet end, may be seen several parallel strips of continuous spectrum, one of considerable strength running through a prominence near the top, and several fainter strips through prominences below the center. Interesting differences will be noted by comparing the shapes of the various lines. The stronger lines like H and K and the hydrogen series show many protuberances. Chief among these may be mentioned a large prominence at the top of the photograph. H and K show a large prominence which was in violent motion and which was at such a high level that it is shown by none of the other lines.

On the original, most of the strong lines show a fine reversal at their centers.

MEASUREMENT OF SPECTRA

The spectrum obtained by means of the parabolic grating extends from λ 3318 to D_3, a distance of 9.5 inches (23.5 cm). From H to D_3 the distance is almost exactly 7 inches (17.78 cm). The dispersion is 1 mm = 10.8 angstroms, about equal to the three-prism dispersion near H_γ, of the Mills spectrograph of the Lick Observatory, or the Bruce spectrograph of the Yerkes Observatory. The dispersion with the flat grating is a trifle greater, and amounts to 9.1 angstroms per millimeter.

All measures were made by the writer at Columbia University. Most of the measures were made by the Repsold engine which has been extensively used at Columbia for the measurement of Rutherfurd photographs. A brass frame was made to carry the spectra. The measures consisted essentially in comparing the lines of the

spectra with a millimeter scale. All errors of the engine, such as division errors of the scale, errors of the micrometer screw, etc., have been most thoroughly investigated. About 10 per cent of the measures were made with the Gaertner machine for measuring stellar spectrograms, a machine similar to the ones used at Yerkes Observatory, and of which the important part is a long screw of half-millimeter pitch. Each measure consisted of the mean of two settings. Each spectrum was separately measured twice. Most of the parabolic grating spectrum was measured three times, considerable of it was measured four times, and some small regions were even measured five times.

The spectra being taken without slit, the lines instead of being straight were crescents, each crescent being a monochromatic image of the chromosphere. Manifestly, erroneous values of wave-lengths would be obtained if the micrometer wire when measuring was made to bisect each line of the spectrum. The chromosphere extends to different heights for different lines above the level defined by the edge of the moon projected on the sun. Exposures for the second flash were begun eight to ten seconds before the end of totality and continued to the end of totality. The flash spectrum is therefore not an instantaneous exposure, but a progressive one. Since the arcs of great elevation like H and K appeared, for the second flash, before those of lower elevation, the base of these arcs may be displaced a slight amount relative to the small low-lying arcs. In addition, for the strong heavy lines like H and K, there is a spreading-out of the photographic image due to irradiation caused by their relatively long exposure. Because of a realization of the above facts as the result of experience gained from similar spectra made in Sumatra for the eclipse of 1901, an attempt was made not to bisect each line, but rather to place the micrometer wire tangent to the spectral arcs on their concave side, which corresponds to the limb of the moon. With the more intense lines of the spectrum, an attempt was made to set the micrometer wire at a slight elevation above the limb of the moon, which, for the photographs measured, was toward the violet end. What success was obtained in this attempt at measurement may be seen by comparing the wave-lengths of the chromosphere with Rowland's values. For all lines

of the chromospheric spectrum taken with parabolic grating, having an intensity less than 25 on the assumed scale, the difference from Rowland averages but 0.02 angstrom, which corresponds to an error of measurement of 0.002 mm. For lines with intensities greater than 25, for the reasons just specified, there are greater differences. Usually for the intense lines, the chromospheric wave-length is too great. The reason for this is assumed to be simply an error in judgment in setting the measuring wire, not enough allowance having been made for the spreading of the heavy lines of the spectrum.

At second flash, the chromospheric light shone through a low-lying plane on the moon's edge. This plane had a sharp termination at one end and a gradual elevation toward the other. The result of this was that the short chromospheric arcs are sharply terminated at one end and gradually dwindle off toward the other. (The meaning of this will be more evident by reference to the photographs.) Advantage of this was taken in the measurements. This sharp termination of the arcs occurred exactly in their middle, as may be seen by looking at the longer arcs. At this sharp edge, the arcs were exactly perpendicular to the length of the spectrum, and consequently all measures for wave-lengths were made by setting the micrometer wire at this sharp termination of the arcs. Unfortunately, for the measurer, the continuous spectrum was rather strong throughout the spectrum and it became necessary to use a strong illumination. (The writer felt great hesitancy about using any chemicals to reduce the continuous spectrum, and he desired to measure the original spectra rather than copies.) This strong illumination tired the eyes rather quickly, and finally incapacitated the eyes for some time, thereby delaying the measurements.

The computing bureau of Columbia University, consisting then of Miss Flora E. Harpham, Miss Eudora Magill, and Miss Helen Lee Davis, assisted by recording and making the reductions to wave-lengths.

DETERMINATION OF WAVE-LENGTHS

Theoretically, both plane and parabolic grating spectra of the chromosphere are normal. Practically, they are not quite normal for the reason that the end of the plate-holder would have cut off

some of the incident light if adjusted to give the normal spectrum. The difference in scale at the two ends of the parabolic spectrum amounted to about one-half of 1 per cent. Consequently, for first approximations to wave-lengths, a constant scale-value was assumed; and setting this value up on a multiplying machine, we were able to obtain wave-lengths with the greatest ease.

During the measurement, it was found that the celluloid film of the parabolic spectrum was very sensitive to changes in temperature, the result being that it became necessary to reduce the lines measured at each sitting separately by themselves.

After obtaining approximate wave-lengths, it was necessary to reduce them to some consistent standard. It was felt that at the present status of the system of wave-lengths it was most advantageous to use Rowland's values. Consequently, comparisons were made with each and every well determined line in the chromosphere which corresponded to a *single* line, *not a blend*, in Rowland. These comparisons for a limited region of measures made at one sitting gave differences which were nearly constant.

The next step in the determination of wave-lengths was an accurate adjustment to Rowland's values. This was done by the well known method of Professor Carl Runge of the University of Göttingen, who, while these reductions were carried on, was Kaiser Wilhelm exchange professor at Columbia University. As each region considered was a comparatively small portion of the spectrum, the method consisted essentially in plotting the differences Mitchell—Rowland and passing a straight line through them. Instead of plotting their differences, the method was to use least squares to determine two constants corresponding to the intercept on the Y-axis and the slope of the tangent. Ordinarily from twenty to forty lines in Rowland could be used as standards. Generally at each sitting a few lines measured at the preceding sitting were remeasured.

Thus piece by piece the measures were reduced to Rowland's scale. Since wave-lengths from the measures at each sitting were reduced separately, the final wave-lengths as given in Table I are the means of the three or four separate measurements. Also, since each measurement was carried on absolutely independently of all

others with the spectra set at different readings of the scale, it is felt that the systematic differences from Rowland, if existing at all, are exceedingly small. For all lines with intensities less than 25, the differences Mitchell—Rowland taken without regard to sign averages almost exactly 0.02 angstrom. Taking account of signs, the average difference is excessively small, showing nothing systematic, except perhaps in some few limited regions.

The differences between chromosphere and Rowland are the result of several causes: First, fundamental differences depending on the distribution of the vapor in the chromosphere. As stated above, there are believed to be no such fundamental differences of wave-length of appreciable size other than those caused by errors in judgment in knowing where to set the micrometer wire for the more intense lines. The second cause for the difference Mitchell—Rowland results from the uncertainty in knowing what wave-length to assume for Rowland for the blended lines. As will be shown later, there are enormous differences in intensities between the Fraunhofer spectrum and the chromospheric spectrum. Manifestly, on account of these differences in intensity, wrong values of wave-lengths would be obtained either by taking an average of the wave-length of the different lines blended, or by weighting them according to their intensities. But what wave-lengths are to be assumed for blended lines? This dilemma is well known to all investigators of stellar spectra. The only logical way for the writer to do was to adopt a rule and stick to it rigidly, and not try to manufacture a wave-length for each Rowland blended line considered. This rule was the one used by most spectroscopists, viz., to weight the lines according to their intensities in Rowland. If necessary to combine with a line 0 on Rowland's scale, this line should have weight 1, and 1 should be added to the intensities of each of the other lines. The third cause of discrepancy between Mitchell and Rowland was, of course, errors of measurement, both in Mitchell and Rowland. The writer sent a glass positive made from a contact print to Mr. John Evershed, and in *Kodaikanal Bulletin No. 27* he estimates the average difference between Mitchell and Rowland for well defined single lines in Rowland to be 0.01 angstrom (corresponding to 0.001 mm error of measurement).

INTENSITIES

The most characteristic difference between the chromospheric and the Fraunhofer spectra is in the intensities. The system of intensities for the chromospheric spectrum is purely an arbitrary one, in which 100 represents the strongest lines like K and H_γ, and 0 that of the weakest line. Naturally the intensities depend on the plate used, but allowance was partially made for the decrease in sensitiveness of the plate in the green and yellow regions. In estimating intensities, one is unconsciously influenced by the breadth of the lines, so that the values for intensity give a somewhat combined estimate of the blackness and breadth of a certain line. These at best are but estimates, but they are perhaps comparable in accuracy with estimates of intensities by others.

The reason for this characteristic difference in intensity is evident on a moment's reflection. Let us consider two different elements in the sun's envelope; one of these elements is low in density and extends high in miles above the sun's photosphere; the other is heavier and its molecules are contained in a shallower layer about the sun. It is easy to imagine that the absorption by the molecules of the two gases traversed by a beam from the sun might be the same, so that the two gases would give lines of equal intensity in the Fraunhofer spectrum. At the time of an eclipse, the exposure is a progressive one. The moon gradually passes before the sun, with the result that the exposure on the low-lying vapor is relatively very short compared with the other assumed vapor of greater elevation. And hence, it is readily seen that though the two gases may give lines of equal intensity in their absorption spectra, they will not do so in their emission spectra; the low-lying heavy vapor will give in the chromosphere short arcs of feeble intensity while the other assumed vapor will give longer arcs of greater intensity. Though there are other contributing causes, the main factor for the differences in intensity between the dark- and bright-line spectra of the sun is the heights to which the vapors extend. H and K and the hydrogen lines are the strongest in the chromosphere mainly for the reason that calcium and hydrogen extend higher than any other elements.

PLATE XV

Spectrum of Chromosphere—Region of H_δ and H_γ

Negative enlarged sixfold

In fact, there are such enormous differences in the two spectra that placed side by side, as they are in Plates XIV, *b*, the spectra seem to belong to stars of two different types, the chromospheric spectrum apparently being of an earlier type than the Fraunhofer spectrum.

In addition to the differences between lines of different elements which depend mainly on elevations, there are enormous differences among the lines of any one element in the two spectra. Generally, the stronger lines in the dark-line spectrum give the stronger lines in the chromospheric spectrum, but not always so. Almost without exception the enhanced lines, or those stronger in the spark than in the arc, give stronger lines in the chromosphere, the differences being generally quite marked. Leaving out of consideration the enhanced lines, one cannot predict from the intensity of a given line in Rowland's tables what the intensity of the line will be in the chromospheric spectrum. In short, in the two spectra, we are dealing with spectra taken under different electrical, thermal, and pressure conditions, and it is but natural to expect as a result that there will be vast differences in intensities.

The chief differences for the stronger lines are found in the elements helium and hydrogen. As is well known, no helium absorption lines are found in the sun. The whole hydrogen series is found in the chromosphere. Perhaps one of the most striking differences between the intensities of lines in the two spectra (which at the same time will illustrate the difficulty experienced in finding the wave-lengths of blended lines), will be seen by referring in Table I to a line in the chromosphere measured at λ 3709.50. In Rowland's tables is a line at λ 3709.389 belonging to *Fe* with an intensity 8. With chromospheric spectra of less accuracy than the present, one would naturally identify the chromospheric line at 3709.50 as a *Fe*-line, especially since this *Fe*-line has an intensity in Rowland of 8. But for the present spectrum, the discrepancy in wave-lengths is too great. The next line in Rowland's tables is an unidentified line at 3709.540 with an intensity oN. Reference to Exner and Haschek's tables shows that this latter line is due both to *Zr* and *V*. In the arc, the lines of both elements are absent;

in the spark the intensity for *Zr* is 15, for *V* is 3. Although this line does not appear in Lockyer's list of enhanced lines, the intensities from Exner and Haschek show that both *Zr* and *V* are enhanced. Consequently, it is seen that the chromospheric line at 3709.50 more nearly corresponds to the weak line at 3709.540 than to the much stronger *Fe*-line at 3709.389. But what wave-length is to be assumed for the blended value of these two lines from Rowland? Manifestly an entirely erroneous value will be obtained if, according to the rule adopted (and given above), the *Fe*-line is given a weight of 9, the other of 1. To show the writer's inability to evaluate the blended line, both wave-lengths are given.

IDENTIFICATION OF LINES

The greatest possible care was exercised in an attempt to identify as many lines as possible of the chromosphere spectrum. While determining wave-lengths, it was necessary to make a close comparison with Rowland's Table of Solar Spectrum Wave-Lengths. To make the identification more complete and to gain information regarding the relative strength in arc and spark spectra, it became necessary to look up practically every table of metallic spectra that had ever been published. During the earlier part of this branch of the present work, the first edition only of Exner and Haschek's tables was published. To go beyond the limit of their wave-lengths (λ 4600), it became necessary to consult Kayser's *Handbuch der Spectroscopie*, Vol. 5 (the sixth volume being still in press), and original sources whenever available. Fortunately, before this part of the work was finished, the 1912 edition of Exner and Haschek's tables appeared, as well as the sixth volume of Kayser.

The method adopted was to take out from the above sources all lines of all metallic spectra which would have a line approximately close to the chromospheric line under investigation, putting down on paper at the same time the intensities in both arc and spark. This work naturally consumed a great amount of time. Upon the arrival of the later edition of Exner and Haschek's tables, a recomparison was made of those elements whose values were different in the two editions. The writer wishes here to express his

appreciation of these splendid volumes. For the purpose in hand, they left almost nothing to be desired. In order to make the present work more uniform, the values of intensities of arc and spark of Exner and Haschek have been adopted throughout.

After having tabulated the intensities of arc and spark from all available sources, it was necessary to choose from these the one or more arc and spark lines which appeared to agree with the lines of the chromosphere. This was a comparatively simple matter on account of the accuracy of wave-lengths of lines of the chromosphere, experience telling which of the possible identifications was the probable one.

In this part of the work many differences were found from the identification given in Rowland's tables, differences expected from the reasons that the present work deals with the chromospheric spectrum and not with the ordinary solar spectrum, and also from the fact that in the quarter-century since Rowland's work was completed, much has been learned concerning the spectra of the metals. Where Rowland has given identifications, they were in most cases found correct.

In Table I, in the column headed "Substance" is given the writer's opinion regarding the identification of the sources of lines in the chromosphere. Following the plan given in Rowland's tables, the sources are arranged in the order of their importance. If a hyphen is given, the first is the important source. If a comma is printed between the two elements, each substance has an equal value in fixing the source of the chromosphere line.

This close comparison with the spectra of the elements made the identification of lines rather certain. But Rowland's tables were made from spectra having a dispersion of approximately ten times the dispersion of the chromospheric spectrum (21-foot radius in the second order compared with 5-foot focus in first order, the gratings having nearly the same number of lines per inch). Naturally, lines which appear single in the chromospheric spectrum may be a blend of two or more lines with the greater dispersion. But lines which appear as a close pair or a blend in the chromosphere must be the result of the blend of corresponding lines in Rowland.

On account of the great differences in intensity of the chromospheric and Rowland spectra, it was difficult to be always sure of identifications until photographs were compared side by side. The original photograph of the flash spectrum was enlarged six times. Rowland's great atlas was reduced five times. Since the flash spectrum was nearly normal, it was possible to procure both spectra on a close approximation to scale. On Plate XIV, *b* are the two spectra printed side by side. This comparison of spectra will perhaps speak more strongly than any words or comparison of wave-lengths concerning the sharpness of the original spectrum of the chromosphere. On account of the small variations from the normal spectrum (noted above) it was impossible to obtain an exact match in scale. Those who are interested sufficiently will carry the comparison along line for line.

The photographs of chromospheric and solar spectra side by side were of the very greatest service in decisions on the relative importance of the sources of the lines of the flash spectrum. Perhaps of the greatest value was the information gained concerning the appearance of the lines in Rowland under the identical dispersion as obtained in the chromospheric spectrum, and from this it was possible to decide rather positively what lines in Rowland become blended under the smaller dispersion. In Table I, under "Intensities, Rowland," is given in parentheses the number of lines which are blended in Rowland's tables, the value of the intensity being naturally the total or combined intensity.

Under "Enhanced Lines," p. 487, will be found further details concerning intensities.

A leave of absence from Columbia University permitted the writer to be at the Yerkes Observatory during 1912–1913. While he was there, most of the identifications, etc., were carried out, and the photographic reproductions were made.

HEIGHTS OF CHROMOSPHERE

These slitless spectra give a ready means of determining the heights to which the vapors forming the chromosphere extend above the photosphere by measurement of the length of the

PLATE XVI

SPECTRUM OF CHROMOSPHERE—REGION SHOWING HYDROGEN λ 4686
Negative enlarged sixfold

chromospheric arcs. For the values herewith given, the sun's semi-diameter was assumed to be 15′50″.7, the augmented semi-diameter of the moon, 16′35″.7. From these semi-diameters were calculated the heights corresponding to various half-lengths of arcs, and a table was constructed (which it is not necessary to print). A protractor was made on glass with a radius equal to that of the chromospheric arcs on the enlarged spectra above referred to. To obtain the length of the arcs, it was necessary only to lay the glass protractor on an enlarged print of the chromosphere and read off degrees from the protractor. The small table gave the corresponding height in kilometers.

The sharp termination of the chromospheric arcs referred to on p. 415 is very near to the middle of the longer arcs. It was assumed that this termination was at the middle of the arcs, and the half-lengths of the shorter arcs were accordingly measured. For the longer arcs, their whole lengths were measured.

In Table I, there is given in the first column the height, in kilometers, to which the chromospheric vapors extend. In the second and third columns are given the wave-lengths of the chromosphere and of Rowland (rounded off to two decimals). In the four last columns are given intensities, those in the two last columns being the values from Exner and Haschek's tables. Since Lockyer's tables of enhanced lines play an important rôle in spectroscopic work, a letter "L" in the "spark" column signifies that the line is an enhanced line according to Lockyer. In some cases, where Lockyer's intensities seemed more reliable than Exner and Haschek's, the estimates of intensity from the former are given. In order to save space in printing, the intensities of the various elements, where more than one form a line, are given in a horizontal line instead of a separate line for each element, as is usually the case in similar tables. The intensities are naturally given in the same order as in the column "Substance."

On the red side of D_3, wave-lengths depend on the plane grating spectrum only. On account of the poorer definition (see above), wave-lengths are given only to tenths of an angstrom instead of to hundredths.

TABLE I

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
400....	3318.16	3318.16	*Ti*	6	2	3	5
300....	3320.42	3320.39	*Ni*	7	0	8	3
400....	3321.84	3321.84	*Ti*	4	2	2	5
600....	3323.03	3323.06	*Ti*	5	5	5	10
350....	3323.88	3323.88	*Fe*	3	0	2	1
400....	3324.19	3324.20	*Cr*	4N	1	1	3
450....	3326.87	3326.91	*Ti*	5	2	3	5
400....	3328.19	3328.25	*V-Cr*	(2) 4	1d	20-1	30-3
400....	3328.99	3329.00	*Fe*	3	1	2	1
600....	3329.57	3329.57	*Ti-Co*	5	5	6-3	10-
500....	3332.25	3332.24	*Ti*	3	3	3	8
600....	3335.34	3335.32	*Ti*	(2) 6	5	5	10
400....	3336.45	3336.43	*Cr-Fe*	(2) 4	1	2-	5-
300....	3336.99	3337.03	*V, Cr*	(2) 1	0	1, 2	1, 1
300....	3337.51	3337.48	*La-Er-Co*	(2) 2	0	8-3-3	15-3-1
350....	3337.99	3337.98	*V-Ti*	2	0	-1	8-3
350....	3339.26	3339.27	*Fe-Ni*	(2) 3	0d	2-	...
500....	3339.89	3339.93	*Cr-Co*	3	3	2-4	10-2
600....	3340.48	3340.48	*Ti*	(2) 5	3	5	6
900....	3341.99	3342.01	*Ti*	(2) 8	8	4	10
500....	3342.77	3342.72	*Cr*	3	2	2	10
300....	3343.50	3343.48	*Sc*	00	0	1	3
500....	3343.86	3343.91	*Ti*	4	2	3	5
300....	3344.64	3344.66	*La*	2	0	8	8
300....	3344.95	3344.92	*Zr*	0	0	3	4
500....	3346.88	3346.88	*Ti-Cr*	(2) 5	2	3-3	5-1
500....	3348.00	3348.02	*Cr-Fe*	(2) 6	2	2-	6-
750....	3349.15	3349.17	*Ti*	(2) 5	4	3	8
1000....	3349.54	3349.58	*Ti-Cr*	(2) 9	10	8-1	10-2
500....	3353.90	3353.88	*Sc*	4	3	20	20
300....	3354.47	3354.52	*Co, Zr*	3	0	5, 2	4, 3
300....	3354.79	3354.78	*Ti*	3	0	8	3
350....	3355.37	3355.36	*Fe*	4	0	2	1
350....	3356.22	3356.23	*Zr*	1	1	4	4
400....	3357.50	3357.45	*Zr, Cr*	(2) 3	2	3, -	4, 4
400....	3358.63	3358.65	*Cr*	4	3	2	10
500....	3360.18	3360.18	*Zr*	2	2	2	4
500....	3360.50	3360.48	*Cr*	1	2	2	20
750....	3361.35	3361.35	*Ti-Sc*	(2) 10	8	10-10	30-8
300....	3362.11	3362.09	*Sc*	2	0	10	8
300....	3366.34	3366.31	*Ti, Ni*	6d?	0	1, 5	3, 3
450....	3366.96	3366.97	*Ni-Fe*	(2) 6	2d?	3-1	2-1
450....	3367.74	3367.75	–	(2) 1	0	...	...
600....	3368.20	3368.19	*Cr-Er*	5d?	5	3-8	20-4
400....	3369.05	3369.08	*Sc*	3d?	1d	15	10
300....	3369.76	3369.71	*Ni-Fe*	6	0	15-3	-2
500....	3371.85	3371.89	*Ti-Ni*	(2) 7	4d?	10-6	2-3
1000....	3372.98	3372.95	*Ti-Er*	(2) 10	12	4-20	20-10
300....	3374.77	3374.81	*Zr-Ni*	(2) 3	1	3-5	5-3
350....	3378.45	3378.48	*Cr-Zr*	2	1	1-1	5-3
400....	3379.49	3379.51	*Cr-Sc*	2	2	1-1	3-3

( ) No. of lines blended

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
500....	3379.98	3379.96	*Cr*	3	3	1	5
600....	3380.41	3380.42	*Ti*	(2) 6	3	5	8
300....	3380.85	3380.86	*Ni, Sr*	(2) 11	0N	13, 20	8, 30
600....	3382.83	3382.82	*Cr*	4	4	2	10
750....	3383.98	3383.95	*Ti*	3	8	3	20
350....	3385.21	3385.20	*Co-Er*	(3) 5	0	4-10	3-8
400....	3387.53	3387.55	*Fe*	2	1	1	1
600....	3388.04	3387.99	*Ti-Zr*	5d?	6	5-3	10-5
350....	3391.55	3391.58	*Cr*	2	1	2	5
400....	3392.12	3392.11	*Zr-Er*	2	2	10-4	20-5
350....	3392.74	3392.78	*Fe-V*	(2) 3	0	5-1	2-4
350....	3393.33	3393.29	*Zr*	1	0	3	4
500....	3393.94	3393.98	*Cr*	2	1	1	4
600....	3394.71	3394.72	*Ti*	(2) 6	5	4	10
350....	3395.50	3395.52	*Co*	(2) 5	0	8	5
300....	3396.50	3396.52	*Zr*	0	0	1	3
400....	3399.35	3399.38	*Fe, Zr*	2	0N	5, 3	2, 4
350....	3401.35	3401.31	*Ni*	1	0	3	1
500....	3402.54	3402.55	*Ti, Cr*	3	2N	1, 1	4, 4
600....	3403.49	3403.46	*Cr-Ni*	(3) 6	4	3−	15−
300....	3404.43	3404.46	*Fe*	(2) 5	1	5	2
300....	3404.92	3404.92	*Zr*	(2) 2	1	3	6
300....	3406.92	3406.94	*Fe-V*	5d?	0	4-2	1-1
300....	3407.34	3407.34	*Ti*	2	0	1	2
300....	3407.65	3407.64	*Fe-Gd*	(2) 7	0	10-5	4-5
600....	3408.94	3408.91	*Cr*	3	5	3	20
350....	3409.92	3409.95	*Ti*	2	2	1	3
350....	3410.36	3410.34	*Zr-Fe*	3	1	4-1	8-1
300..	3412.60	3412.61	*Co*	(2) 9	0	20	7
300.. Many faint lines	3415.06	....	...	...	0	...	...
300..	3416.02	....	...	...	0	...	...
300..	3416.58	....	...	...	0	...	...
300..	3420.33	....	...	...	1	...	...
600..	3421.37	3421.35	*Cr*	4	4	3	10
600..	3422.84	3422.85	*Cr-Fe-Ce*	(2) 7	5	3-3-3	20-2-2
300....	3423.85	3423.85	*Ni*	7	0	10	5
300....	3424.40	3424.43	*Fe*	4	0	4	2
300....	3425.13	3425.15	*Fe*	4	0	2	1
300....	3425.66	3425.72	–	2	0	...	...
300....	3426.46	3426.50	*Fe*	(2) 6	0	3	1
500....	3430.70	3430.67	*Zr*	1	3	4	10
400....	3431.72	3431.72	*Co, Zr*	4	0	8, 1	4, 3
450....	3432.56	3432.55	*Zr*	00	1	1	4
600....	3433.48	3433.45	*Cr*	3	8	2	5
300....	3436.05	3436.10	*Cr*	(3) 3	0N	5	4
400....	3437.35	3437.34	*Ni-Fe*	(2) 8	1d	8−	5-1
500....	3438.36	3438.38	*Zr*	2	3	8	20
350....	3439.11	3439.13	*Mn-Fe*	(2) 4	1d	1−	3−
400....	3440.13	3440.14	*Gd*	000N	1	8	6
500....	3440.75	3440.76	*Fe*	20	2	30	4
500....	3441.15	3441.16	*Fe*	15	2	30	4

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
600....	3442.12	3442.12	*Mn*	6	7	2	30
400....	3443.37	3443.33	*Co*	0	1	3	3
500....	3444.03	3444.02	*Fe*	8N	2	15	3
500....	3344.44	3444.47	*Ti*	4	3	4	10
300....	3445.20	3445.26	*Fe*	5	0	5	2
350....	3445.69	3445.74	*Cr-Dy*	2N	0	3-10	2-3
500....	3446.38	3446.41	*Ni*	15	2	30	10
300....	3446.54	3446.54	–	1Nd?	0	...	...
300....	3447.43	3447.42	*Zr-Fe*	4	0	3-2	3-1
300....	3449.00	3449.00	*Y*	0	0	5	5
300....	3449.60	3449.58	*Co*	6d?	0	10	5
300....	3450.52	3450.47	*Fe-Gd*	5	0	3-6	1-6
300....	3452.04	3452.06	*Fe*	3	0	3	1
400....	3452.60	3452.61	*Ti*	1	2	1	8
300....	3453.02	3453.04	*Ni*	6d?	0	10	5
300....	{3453.45	{3453.47	*Cr*	0	0	3	2
300....	{3453.69	{3453.65	*Co*	(2) 5	0	20	10
300....	3454.32	3454.30	*Ti*	1	0	1	1
300....	3455.43	3455.38	*Co*	5	0	3	3
300....	3455.91	....	...	...	0	...	...
350....	3456.16	3456.15	*Er-Nh*	∞	1	6-30	2-30
400....	3456.59	3456.53	*Ti*	3	3	2	10
300....	3457.78	3457.72	*Zr-Cr*	0	0	3–	6-4
350....	3458.51	3458.56	*Ni-Fe*	(2) 11	1d	20-2	10-1
350....	3459.10	3459.07	*Zr*	∞	0	2	5
400....	3459.56	3459.57	*Ce-Fe*	2	1	–1	4–
350....	3460.05	3460.06	*Zr-Fe*	(3) 6	0	3-2	2-1
400....	{3461.59	3461.63	*Ti*	5	3	3	10
400....	{3461.78	3461.80	*Ni*	8	3	20	10
300....	3462.92	3462.95	*Co*	6	0	10	5
300....	3463.27	3463.30	*Zr-Fe*	(2) 2	1d	3-1	15–
300....	3464.21	3464.27	*Sr-Gd-Er*	(3) 4	1N	30-6-4	50-6-2
500....	3465.89	3465.90	*Co*	4	2	10	5
350....	3468.95	3468.99	*Fe*	2	0d?	1	1
350....	3471.42	3471.45	*Zr-Co*	(2) 6	0	3-3	4-2
500....	3473.75	3473.74	*Fe?*	(3) 2	2	...	...
600....	3474.27	3474.24	*Mn*	4	5	1	15
300....	3475.29	3475.27	*Cr*	2	0	1	3
400....	3475.56	3475.59	*Fe*	10	2	10	3
400....	3476.85	3476.85	*Fe*	8	0	10	3
500....	3477.32	3477.32	*Ti*	5	4	3	10
300....	3478.74	3478.74	*Zr*	(2) 1	0	1	2
350....	3479.55	3479.53	*Zr*	2	1	4	10
300....	3480.53	3480.55	*Zr-Er*	(2) 3	0	2-3	3-3
300....	3481.04	3481.02	*Ti*	2	0	...	2
400....	3481.35	3481.30	*Zr*	2	2	4	15
500....	3483.06	3483.05	*Mn*–	5d?	4	2–	12–
350....	3483.79	3483.78	*Zr-Ni-Co*	(3) 9	1N	3-8-4	7-4-3
300....	3485.10	3485.12	*Fe*	(3) 4	0	1	...
300....	3485.50	3485.49	*Fe, Co, Zr*	6	0	3, 4, –	2, 3, 3
300....	3486.07	3486.04	*V-Ni*	5	0	2-5	6-2

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
400....	3488.22	....	...	...	1	...	...
500....	3488.80	3488.82	*Mn*	4	4	2	10
350....	{3489.56	{3489.55	*Co*	5	0	20	8
400....	{3489.87	{3489.84	*Ti, Fe*	(2) 5	3	1-2	2-1
400....	3490.75	3490.73	*Fe*	10N	3	20	4
500....	3491.20	3491.20	*Ti*	5	4	3	5
350....	{3493.06	3493.11	*Ni*	10	1	30	10
350....	{3493.27	3493.31	*V*	0N	1	2	5
300....	3494.32	3494.31	*Fe*	2	0	...	...
300....	3494.78	3494.82	*Fe*	2	1	...	...
350....	3495.41	3495.46	*Cr-Fe*	(2) 5	2d?	1-3	3-1
400....	3495.80	3495.82	*Co-Ti*	(2) 5	2	5-1	5-1
500....	3496.32	3496.32	*Zr-Y*	(2) 2	4	10-10	20-10
350....	3497.13	3497.15	*V*	1	1	2	8
400....	3497.71	3497.67	*Mn*	3	2	1	6
300....	3498.86	3498.89	–	1	0	...	...
350....	3499.27	3499.25	*Er-Ti*	0	1	15–	10-1
400....	3500.57	3500.57	*Ti-Fe*	(2) 5	1d	1-1	2-1
300....	3501.03	3501.00	*Ni-V*	6d?	0	6-2	4-2
300....	3502.62	3502.56	*Co-Ni*	(4) 10	0d	19-3	9-1
400....	3504.58	3504.58	*V*	2	2	3	1
600....	3505.05	3505.06	*Ti*	2	5	3	30
400....	3505.76	3505.75	*Zr-V*	(2) 1	1d	5-3	20-2
350....	3506.57	3506.56	*Co-Fe-Ti*	(3) 9	0d	10-2-2	8-1-1
350....	3508.56	3508.59	*Fe*	(3) 6	0d	2	1
350....	3510.00	3509.99	*Co*	4	1	8	5
400....	3510.45	3510.47	*Ni*	8	1	15	10
600....	3511.02	3510.98	*Ti*	5	5	3	30
300....	3512.00	3511.98	*Cr-Mn*	2	0	1-1	4-1
350....	3512.76	3512.78	*Co*	6	1	10	6
350....	3513.66	3513.62	*Co*	5	1	4	4
350....	3513.99	3513.97	*Fe*	7	1	10	3
350....	3514.18	3514.14	*Ni*	3	1	5	8
500....	3515.14	3515.14	*Ni-Fe*	(2) 14	2d	30-1	10–
300....	3516.36	3516.36	*Ni*	2	0	2	1
300....	3516.70	3516.70	*Fe*	2	0	1	...
400....	3517.48	3517.45	*V-Ce*	3	2	3-3	20-2
300....	3518.95	3518.92	*Fe*	(2) 6	0	2	...
400....	3519.87	3519.90	*Ni-Zr*	7	2d?	6-4	3-3
500....	3520.38	3520.40	*Ti*	2	3	2	8
300....	3521.01	3520.99	*Zr*	2	0	...	3
300....	{3521.48	{3521.50	*Fe–*	(2) 11	1	10	3
300....	{3521.86	{3521.83	*Co-V*	(2) 6	0	3-1	5-5
300....	3523.08	3523.05	*Fe, Co*	2	0	1, 2	–, 1
500....	3524.04	3523.99	*Co-Fe*	(3) 10	2d	4-2	5-4
500....	3524.66	3524.68	*Ni*	20	3	50	15
300....	3524.92	3524.88	*V*	1	0	2	8
400....	{3525.91	{3525.91	*Zr–*	(4) 6	1	2	4
400....	{3526.45	{3526.45	*Fe*	(4) 9	1	7	3
300....	3527.92	3527.94	*Fe*	5	0	3	1
350....	3529.13	3529.14	*Co-Ni*	(2) 4	1	5–	3–

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
350....	3529.85	3529.85	*Co-Fe*	(3) 9	1	15-3	6-1
500....	3530.86	3530.92	*V*	3	2	3	20
500....	3531.76	3531.82	*Mn-Dy-Fe*	(3) 6	2d	3-20-	3-20-
300....	3532.64	3532.72	*Fe, V*	4	0	1, –	–, 3
400....	3533.35	3533.33	*Fe-Co*	(3) 17	0d	7-5	3-4
300....	3534.03	3534.00	*Ti*	1	0	...	2
350....	3535.05	3535.06	*Fe*	3	1	1	...
500....	3535.55	3535.55	*Ti*	4	5	2	15
400....	3535.83	3535.87	*Sc*	3	1	10	15
350....	3536.70	3536.71	*Fe*	7	1	5	3
300....	3538.40	3538.40	*V*	1	0	1	4
350....	3541.22	3541.24	*Fe*	7	0	8	3
350....	3542.30	3542.29	*Fe*	(2) 9	0	8	3
300....	3543.50	3543.47	*Co-Fe*	(2) 4	0	5-1	...
350....	3544.19	3544.16	*Ce-C*	000	0	...	3–
500....	3545.33	3545.34	*V*	4	3	3	30
350....	3545.83	3545.85	*Fe-Gd*	(2) 8	1	3-10	1-10
300....	3547.41	3547.36	*Fe-C*	3	0d?	1	...
350....	3548.10	3548.14	*Mn-Ni*	(3) 13	1	23-3	10-3
400....	3549.12	3549.15	*Y*	2	2	10	20
350....	3549.52	3549.51	*Gd-C*	0	0	10	10
300....	3550.73	3550.74	*Co*	4	0	5	3
350....	3551.55	3551.59	*Ni-C*	(2) 5	1	3–	2–
350....	3552.06	3552.10	*Zr*	1	2	6	20
300....	3553.15	3553.13	*Co*	1	0	3	2
350....	3554.25	3554.26	*Zr-Fe*	5	0	–3	4-1
350....	3555.06	3555.08	*Fe*	9	0	8	4
350....	3555.23	3555.18	*C–*	0	1	...	...
400....	3556.16	3556.09	*C*	000Nd?	1	...	...
500....	3556.85	3556.89	*V, Zr-Fe*	(4) 11	4	3, 8-5	50, 20-2
350....	3557.94	....	...	...	0	...	...
500....	3558.66	3558.67	*Sc, Fe*	8	2	20, 10	20, 4
300....	3559.24	3559.22	*Fe-C*	1	0	1–	...
300....	3559.64	3559.66	*Fe*	3	0	1	...
350....	3561.05	3561.04	*Co, Ce*	4	1	4, 4	4, 4
400....	3561.54	....	*C*	...	0	...	...
300....	3562.02	3562.04	*Ti*	1	0	1	2
350....	3564.61	3564.66	*Ti*	3	1	1	...
500....	3565.49	3565.54	*Fe*	20	4	20	5
300....	3566.08	3566.11	*Ti*	1	0	1	3
350....	3566.28	3566.31	*V*	2N	1	2	8
300....	3567.14	3567.14	*Fe*	(2) 3	0	1	2
400....	3567.90	3567.88	*Sc*	2	2	20	20
300....	3568.73	3568.78	*Fe*	(2) 6	0N	1	...
500....	3569.69	3569.65	*Co, Mn*	(3) 11	3	20, 25	10, 9
500....	3570.34	3570.27	*Fe*	20	3	50	10
400....	3572.10	3572.08	*Ni, Fe*	(2) 11	1	10, 3	3, 2
500....	3572.66	3572.67	*Sc-Zr*	(2) 10	5	30-8	50-15
300....	3573.53	3573.54	*Fe-Ti*	(5) 12	0	4-2	3-2
400....	3574.11	3574.05			2		

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
300....	3574.57	3574.56	*V-La-C*	1	0	-3-	3-1-
400....	3575.49	3575.53	*Fe-Co*	(7) 16	1	4-3	2-5
600....	3576.52	3576.53	*Sc*	3	6	20	30
350....	3577.03	3577.00	*Zr*	1	2	5	15
400....	3577.96	3578.01	*Mn-V*	5	2	10-3	5-2
400....	3578.36	3578.36	*Zr-Ti*	00	1	-1	3-1
500....	3578.87	3578.83	*Cr*	10	3	30	20
600....	3581.11	3581.07	*Sc*	5	3	10	20
600....	3581.36	3581.35	*Fe*	30	4	50	10
300....	3582.12	3582.08	*Zr-Fe*	(3) 8	0	-2	3-2
350....	3582.47	3582.47			1		
350....	3584.01*	3584.05	*C*–	3	0	...	...
450....	3584.82	3584.80	*Fe*	6	3	4	2
450....	3585.09	3585.10	*Fe, Gd*	6	3	2, 10	2, 10
600....	3585.44	3585.41	*Cr, Fe*	(2) 12	5	4, 5	4, 3
300....	3585.76†	3585.81	*Fe-Cr-C*	(2) 8	0	5–	3-3-
300....	3586.67	3586.68	*Mn*		0	5	4
400....	3586.97	3587.02	*Al-Fe*	(6) 24	1	–8	100-3
400....	3587.34	3587.37	*Co*		1	15	10
350....	3587.68	3587.78	*Fe-C*	(2) 8	0	3	2
350....	3588.12	3588.08	*Ni-Zr*	6	0	3-3	2-3
350....	3588.76	3588.76	*Fe*	4	0	3	1
350....	3589.27	3589.25	*Fe*	4	1	4	1
600....	3589.86	3589.84	*V-Sc*	(2) 10	8	4-10	20-10
500....	3590.62‡	3590.63	*Sc-Gd-C*	(2) 4	2N	15-4	10-4
400....	3591.57	3591.56	*Fe*	(2) 4	1d	1	...
450....	3592.13	3592.17	*V*	2	3	3	20
350....	3592.81	3592.82	*Gd-Fe*	4	0	6-1	8–
500....	3593.55	3593.60	*V, Cr*	(2) 12	4	2, 30	15, 20
400....	3594.92	3594.86	*Fe-Co*	(2) 9	1d	4-8	2-4
350....	3595.34	3595.38	*Mn-Fe*	(2) 3	0	4–	2–
500....	3596.17	3596.20	*Ti*	4	4	3	5
350....	3597.17	3597.19	*Fe*	5d?	0	1	...
350....	3597.85	3597.85	*Ni*	8	1	10	6
350....	3598.29	....	...	...	0	...	...
350....	3599.36	3599.36	*Fe*	(4) 9	1d	2	1
400....	3600.28	....		...	1	...	...
600....	3600.91	3600.88	*Y*	3	6	20	50
600....	3602.03	3602.06	*Y*	4	1	10	20
300....	3602.64	3602.65	*Fe*	(2) 7	0N	3	3
350....	3603.31	3603.35	*Fe*	5	1	4	3
500....	3603.95	3603.92	*Cr*	3	4	...	10
350....	3604.70	....	*C*	...	0	...	...
500....	3605.48	3605.48	*Cr*	7	3d	30	20
400....	3606.83	3606.84	*Fe*–	6	1	8	4
300....	3607.60	3607.60	*Zr-Mn*	(2) 3	0d	2-5	5-3
500....	3609.00	3609.01	*Fe*	20	3	20	6
300....	3609.50	3609.47	*Ni*	5d?	0	5	2

* Third edge of fourth cyanogen band.
† Second edge of fourth cyanogen band.
‡ First edge of fourth cyanogen band.

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
400....	3609.70	3609.63	*Sa-Pd*	(2) 3	1	4-100	4-50
500....	3610.55	3610.56	*Ti-Fe-Ni-Mn-Cd*	(5) 19	2N	4-6-10-5-500	2-3-4-3-100
500....	3611.20	3611.19	*Y*	2	3	20	30
350....	3611.95	3611.92	*Zr-Co*	(2) 2	1	3-4	10-2
350....	3612.86	3612.88	*Ni*	6d?	1	6	3
750....	3613.96	3613.95	*Sc*	4	10	30	100
400....	3614.89	3614.92	*Zr*	2	2	4	10
350....	3616.71	3616.71	*Er-Fe*	4	0	10-1	8-1
400....	3617.96	3617.93	*Er-Fe*	6	1	5-4	5-3
600....	3618.91	3618.92	*Fe*	20	6	20	6
350....	3619.56	3619.54	*Ni*	8	2	50	15
300....	3619.90	3619.92	*Fe*	2	0	...	...
300....	3620.37	3620.39	*Fe*	2	0	...	...
300....	3620.60	3620.61	*Fe-Gd*	3	0	1-3	1-3
450....	3621.32	3621.34	*V-Co*	2	3	1-1	6-4
400....	3622.13	3622.15	*Fe*	6	2	4	3
400....	3623.44	3623.43	*Fe*	(2) 7	1d	4	2
350....	3623.99	3623.95	*Zr-Mn*	(2) 5	0	5-4	4-2
400....	3624.53	3624.56	*Ni-Ca*	(3) 10	1d	3-10	2-2
500....	3624.98	3624.98	*Ti-Fe*	5	8	2-1	8-
400....	3627.99	3627.95	*Co, V*	4	1	5-	4, 3
400....	3628.85	3628.85	*Y*	2	2	10	10
500....	3630.15	3630.16	*Zr*	1	2	1	5
750....	3630.87	3630.88	*Sc*	4	12	20	100
600....	3631.61	3631.60	*Fe*	15	6	20	6
400....	3632.15	3632.16	*Fe-Er*	(2) 5	1	3-5	2-4
400....	3632.80	3632.77	*Fe-Cr*	(2) 4	0	2-3	1-2
500....	3633.27	3633.28	*Y*	2	2	20	30
400....	3633.61	3633.65	*Zr-Ti*	00Nd?	0	-2	6-1
400....	3634.40	(3634.39)	*He*	...	1	...	...
350....	3635.49	3635.51	*Ti-Fe*	(2) 6	1d	17-1	4-1
350....	3636.32	3636.33	*Fe*	(2) 5	0	2	1
350....	3636.70	3636.69	*Zr-Cr*	(2) 3	1	1-4	4-3
350....	3638.45	3638.44	*Fe*	3	0	4	1
350....	3639.56	3639.56	*Co*	2	0	3	2
350....	3639.94	3639.94	*Cr*-	2	0	5	5
400....	3640.55	3640.54	*Fe*	6	2	5	3
600....	3641.48	3641.47	*Ti*	4	8	3	10
500....	3641.95	3641.96	*Cr-Co*	(2) 2	1	3-3	3-1
600....	3642.88	3642.84	*Sc-Ti*	(2) 9	8	20-15	50-3
400....	3644.54	3644.55	*Ca*	5	0	20	4
600....	3644.97	3645.01	*Fe, Ca*	(3) 6	2d	-, 8	1, -
600....	3645.48	3645.48	*Sc*	3	4	15	15
400....	3646.31	3646.34	*Ti, Gd*	1	0d?	2, 15	2, 12
350....	3647.11	3647.13	-	2	0	...	...
400....	3647.54	3647.56	*Fe*	4	1	1	1
600....	3647.94	3647.99	*Fe*	12	5	30	6
400....	3649.70	3649.65	*Fe, La*	5	0	3, 2	3, 1
400....	3650.32	3650.31	*Fe-La*	(2) 9	0	2-3	4-4
400....	3650.87	(3650.90)	*Zr*	...	0	...	4

TABLE I—*Continued*

HEIGHT OF CHROMOSPHERE	WAVE-LENGTHS		SUBSTANCE	INTENSITIES			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
400....	3651.60	3651.61	*Fe*	7	1	5	3
600....	3651.90	3651.94	*Sc*	4	4	10	20
500....	3653.62	3653.64	*Ti*	5	1N	15	4
350....	3654.07	3654.05	*Cr*	2	1	2	3
350....	3654.80	3654.76	*Ti, Gd*	(2) 3	0	3, 8	2, 8
400....	3655.78	3655.80	*Zr*	3	2	...	4
400....	3656.33	3656.39	*Cr-Fe-Gd*	(2) 5	2	2-8	3-2-8
400....	3656.80	(3656.81)	H_{35}	...	1	...	...
400....	3657.40	(3657.41)	H_{34}	...	1	...	...
400....	3658.19	(3658.07)	H_{33}	...	1d	...	...
		3658.24	*Ti*	1		4	3
400....	3658.80	(3658.78)	H_{32}	...	1	...	...
750....	3659.88	3659.90	*Ti**	5	5d	2	10
500....	3660.47	(3660.42)	H_{30}	...	1	...	...
		3660.47	*Fe*	2		...	1
500....	3661.42	(3661.38)	H_{29}	...	2	...	...
750....	3662.37	(3662.40)	H_{28}	...	4	...	...
		3662.38	*Ti*	5		2	10
350....	3663.07	....	...	...	0	...	...
750....	3663.56	(3663.56)	H_{27}	...	2	...	...
		3663.51	*Fe*	(3) 9		2	...
1500....	3664.80	3664.76	*Y-Gd*	2	4	20-8	20-15
		(3664.82)	H_{26}	...		...	...
350....	3665.41	....	...	...	0	...	...
1500....	3666.23	(3666.24)	H_{25}	...	3	...	...
350....	3666.88	3666.91	*Fe*	3	0	1	...
500....	3667.40	3667.40	*Fe*	4	1	2	1
1500....	3667.91	(3667.83)	H_{ω}	...	4	...	...
500....	3668.69	3668.63	*Zr, Y*	∞	1	–, 3	4, 10
1500....	3669.60	(3669.61)	H_{ψ}	...	5	...	...
350....	3670.26	3670.24	*Fe*	2	0	2	1
350....	3670.60	3670.57	*Ni*	5	1	4	2
1500....	3671.45	3671.41	*Zr*	0	6d	2	10
		(3671.62)	H_{χ}	...		...	...
350....	3671.82	3671.82	*Ti*	3	1	4	3
350....	3673.22	3673.23	*Fe-Er*	3	1	–1	–2
1500....	3673.96	(3673.91)	H_{ϕ}	...	5	...	...
500....	3674.84	3674.86	*Zr-V*	1	2	3–	15-3
350....	3675.47	3675.43	*Sc*	1	0	2	1
1500....	3676.48	3676.46	*Co-Fe*	6	6	1-3	6-1
		(3676.51)	H_{υ}	...		...	...
400....	3677.51	3677.52	*Fe*	(2) 7	1	2	3
500....	3677.94	3677.91	*Cr*	(2) 6	4	2	6
2000....	3679.48	(3679.50)	H_{τ}	...	8	...	...
500....	3680.08	3680.07	*Fe*	9	2	10	3
350....	3681.11	3681.08	*Fe–*	(3) 9	1	3	4
500....	3682.35	3682.38	*Fe*	5	2	5	3
2000....	3682.96	(3682.95)	H_{σ}	...	10	...	...
6000....	3685.41	3685.34	*Ti*	10d?	40	8	100
600....	3686.24	3686.23	*Fe, V*	(2) 9	3	3, 3	2, 3

* H_{31} at λ 3659.57.

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
2000....	3686.97	(3686.98)	H_ρ	...	12	...	...
400....	3687.76	3687.72	*Fe-V*	(2) 10	1	10-10	5-3
400....	3689.64	3689.61	*Fe*	6	1	3	2
2500....	3691.78	(3691.70)	H_π	...	15	...	...
400....	3692.38	3692.36	*V*	1	1	10	4
350....	3692.81	3692.79	*Er-Fe*	2	0	20-1	10-
350....	3693.16	3693.17	*Fe*	3	0	1	...
500....	3693.62	3693.62	*Co*	1	2	5	4
500....	3694.27	3694.24	*Fe-Ni-*	(4) 10	4	4-3	2-
400....	3695.11	....	...	...	1	...	...
3000....	3697.35	(3697.30)	H_o	...	20	...	...
500....	3698.28	3698.30	*Zr-Ti*	2	2	3-1	20-1
350....	3699.30	3699.28	*Fe*	3	0	1	...
350....	3700.53	3700.48	*V*	1	1	1	8
350....	3701.23	3701.23	*Fe*	8	0	4	2
350....	3702.41	3702.40	*Co, Ti*	(2) 4	1	5, 2	6, 2
4000....	3704.03	(3704.00)	H_ξ	...	25	...	...
750....	3705.11	(3705.15)	*He*	...	1	...	...
750....	3705.71	3705.71	*Fe*	9	4	20	4
750....	3706.25	3706.24	*Mn-Ti-Ca*	(2) 9	10	2-2-10	50-8-50
400....	3707.22	3707.19	*Fe*	5	1	2	1
400....	3708.08	3708.07	*Fe*	5	1	20	4
350....	3708.83	3708.85	*V-Ti*	(2) 2	0	3-1	2-1
400....	3709.50	3709.39 3709.54	*Fe* *Zr-V*	8 0N	4	20 ...	4 15-3
600....	3710.49	3710.43	*Y*	3	8	30	100
6000....	3712.20	(3712.12)	H_ν	...	30	...	...
500....	3713.03	3713.06	*Cr*	(2) 5	4	1	6
300....	3713.65	3713.69	*La*	000N	1	4	6
450....	3714.99	3714.93	*Zr*	0	2	1	6
600....	3715.57	3715.61	*V*	4	4	3	20
400....	3716.53	3716.59	*Fe-Ce-Gd*	7	2N	3-3-5	2-3-4
400....	3717.54	3717.54	*Ti*	2	1	5	2
350....	3717.96	3717.98	–	0	1	...	...
400....	3718.54	3718.55	*Fe-Ce*	4	2	2-3	1-3
1500....	3720.08	3720.08	*Fe*	40	10	50	10
6000....	3722.20	(3722.08)	H_μ	...	35	...	...
400....	3722.69	3722.69	*Fe-Ti-Ni*	(2) 10	2	20-3-5	4-3-1
350....	3723.69	3723.68	*Nd-*	(2) 2	2	4	3
400....	3724.20	3724.23	*Ti*	1	2	...	2
400....	3724.54	3724.53	*Fe-Er*	6	2	3-3	2-4
350....	3725.14	3725.13	*Ti-Ni-Eu*	(2) 2	2	4-1-30	3-1-20
400....	3727.12	3727.14	*Fe*	(2) 7	1	3	2
450....	3727.53	3727.55	*V-*	(3) 2	2	2	20
500....	3727.82	3727.79	*Fe-Zr*	(2) 5	3	15-	5-7
350....	3728.52	3728.54	*V-Ce*	00	1	1-3	4-3
350....	3730.00	3729.95	*Ti-Zr*	3	0	8-	4-3
350....	3730.53	3730.57	*Co-Fe*	(2) 5	1	5-2	5-1
350....	3731.34	3731.32	*Zr-Fe*	(3) 6	2	-4	15-2
350....	3732.12	3732.15	*Cr-Mn*	(2) 2	0	3-1	2-3
350....	3732.54	3732.54	*Co-Fe*	6	1	5-4	8-3

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
350....	3732.90	3732.89	*V*	2	1	3	20
6000....	3734.68	(3734.51)	*Hλ*	...	40	...	...
750....	3735.05	3735.01	*Fe*	40	2	50	10
350....	3735.60	3735.59	*C*	000	0	...	...
1500....	3737.14	{3737.02	*Ca-Ni*	(2) 8	25	20-5	50-3
		3737.28	*Fe*	30		30	7
400....	3737.81	3737.81	*C*	(2) 0	0	...	...
500....	3738.43	3738.47	*Fe*	(2) 6	0d	2	2
500....	3739.28	3739.33	*Fe, Ni*	(3) 5	1	1, 3	–, 2
500....	3739.89	3739.89	*Fe-Ni*	(3) 6	1d	2-1	2–
300....	3740.49	3740.48	–	0	0	...	...
1500....	3741.78	3741.79	*Ti*	4	15	3	10
300....	3742.38	3742.41	*C*	00	0	...	...
600....	3743.63	3743.67	*Fe-Cr-Gd*	(5) 12	4d	15-7-10	6-6-10
400....	3744.25	3744.25	*Fe*	4	1	2	1
1500....	3745.92	3745.86	*Fe-V*	(2) 14	20d	30-4	9-20
300....	3746.67	3746.65	*Fe-Mn*	(2) 3	0	1-1	1-1
600....	3747.74	3747.69	*V*	1	4	5	10
750....	3748.39	3748.41	*Fe*	10	8	20	4
6000....	3750.41	(3750.30)	*Hκ*	...	45	...	...
500....	3751.79	3751.80	*Zr*	00	1	3	20
300....	3752.35	3752.37	*C*	00	0	...	...
500....	3753.69	3753.73	*Fe, Ti*	6	2	3, 3	2, 3
300....	3754.33	3754.37	*C*	00	0	...	...
300....	3754.65	3754.66	–	(2) 4	0	...	...
350....	3755.55	3755.59	*Co-C*	1	0	3	4
300....	3756.18	3756.21	*Fe-Er*	3	0	1-3	–1
600....	3757.30	3757.26	*Fe-Cr*	(3) 7	2	2-2	1-2
750....	3757.80	3757.82	*Ti-Cr*	4	10	2-3	6-2
6000....	3759.47	3759.45	*Ti*	12d?	45	10	L20
6000....	3761.47	3761.46	*Ti*	7	40	6	L10
750....	3762.02	3762.01	*Ti*	3	1	1	L4
500....	3762.49	3762.47	*C–*	(2) 2	0	...	...
1000....	3763.93	3763.94	*Fe*	10	4	20	6
800....	{3764.68	3764.69	*C*	(5) 1	1	...	...
800....	3765.63	3765.69	*Fe*	6	2	4	3
500....	3766.45	3766.47	*C*	1	0	...	...
750....	3766.82	3766.84	*Zr-Fe*	(2) 4	2	4-1	10–
1000....	3767.29	3767.34	*Fe*	8	8	15	5
750....	3768.35	3768.38	*C*	2	2	...	...
6000....	3770.90	(3770.78)	*Hι*	...	50	...	...
400....	3771.80	3771.80	*Ti-C*	2	1	4	3
400....	3772.31	3772.29	*C*	1	0	...	...
300....	3772.71	3772.69	*Ni–*	(2) 3	0	2	1
400....	3773.04	3773.07	*C*	0N	1	...	...
500....	3773.90	3773.90	*C-Fe*	(5) 4	2	...	...
750....	3774.52	3774.47	*V*	3	10	20	100
600....	3775.68	3775.72	*Ni*	7	3	8	5
600....	3776.16	3776.20	*Ti*	2	3	1	L4
500....	3777.77	{3777.59	*Fe*	3	2N	1	1
		3777.98	*C*	0		...	...

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
450....	3778.44	3778.42	*Fe-V-Ni*	(^{3}) 7	1	1-1-1	1-3-1
450....	3779.53	3779.57	*Fe-C*	4	2	1-	1-
450....	3780.62	3780.61	*C*	0	1	...	...
450....	3781.80	3781.77	*C-Ce*	1	1	3	3
500....	3782.40	3782.39	*C-Y-Zr-Gd*	(^{2}) 0	1	- - - 4	-5-3-12
750....	3783.61	3783.63	*Ni-C*	(^{2}) 8	5d	8	5
500....	3784.29	3784.28	*C*	(^{4}) 2	1	...	...
500....	3785.29	3785.54	*C*	(^{4}) 2	0	...	...
500....	3785.72				0		
600....	3786.31	3786.31	*Fe, Ti*	4d?	1	2, 3	2, 2
450....	3787.25	3787.30	*C-Fe*	1	0	...	...
750....	3788.06	3788.05	*Fe-Er*	9	2	10-6	4-3
800....	3788.80	3788.84	*Y*	2	8	20	30
450....	3789.14	3789.14	*C*	(^{2}) 1	0	...	...
750....	3790.23	3790.24	*Fe*	5	2	4	2
500....	3790.56	3790.58	*V-C*	(^{3}) 2	1	6-	4-
750....	3790.92	3790.93	*La-C*	(^{2}) 3	2	8-	50-
500....	3791.50	3791.52	*Zr-C*	1	1	4-	3-
600....	3792.65	3792.64	*C-Fe-Ni*	(^{6}) 8	2N	...	...
500....	3793.48	3793.46	*Cr-*	(^{2}) 2	1	2	2
500....	3793.87	3793.88	*C*	0	1	...	...
500....	3794.45	3794.48	*Fe-V-C*	4	2	2-1-	-3-
900....	3794.90	3794.91	*La*	1	4	10	50
450....	3795.33	3795.15	*Fe*	8	0	10	5
		3795.48	*C*	0		...	...
500....	3795.84	3795.88	*Er-C*	00	1	...	4
600....	3796.39	3796.40	*Zr-Gd-C*	(^{3}) 1	1	-10-	10-10-
6000....	3798.15	(3798.05)	*Ho*	...	50	...	...
750....	3799.66	3799.69	*Fe-C*	7	3	10	5
450....	3800.20	3800.21	*C*	0	1	...	...
500....	3801.51	3801.54	*C*	(^{3}) 2	2d	...	...
450....	3802.42	3802.42	*Fe-Nd*	2	1	1-2	1-2
450....	3802.85	3802.91	*C*	(^{2}) 1	1	...	...
500....	3803.14	3803.18	*C*	(^{2}) 2	2	...	...
500....	3803.56	3803.62	*V*	0	1	4	3
600....	3804.14	3804.15	*C-Fe*	3	2	-1	...
600....	3804.79	3804.79	*C*	(^{2}) 2	2	...	...
750....	3805.46	3805.49	*Fe-Ni-C*	6	2N	4-5-	1-3-
600....	3806.29	3806.33	*Fe-C*	2	1	1	1
500....	3807.45	3807.49	*Ni-V-Fe*	(^{2}) 12	2	8-3-4	7-2-3
450....	3807.82	3807.83	*C*	00	1	...	...
450....	3808.23	3808.27	*C*	1	2N	...	...
450....	3809.25	3809.23	*C*	(^{2}) 1	1	...	...
450....	3809.84	3809.86	*C*	(^{2}) 1	1	...	...
500....	3810.98	3810.97	*Fe-C*	(^{2}) 4	2	1	1
450....	3811.54	3811.48	*C*	(^{2}) 2	1	...	...
500....	3812.14	3812.16	*C*	(^{2}) 1	1	...	...
700....	3813.24	3813.18	*Fe-C*	(^{3}) 7	8N	10-	4-
600....	3813.63	3813.64	*Ti-V-Fe-C*	(^{3}) 4	2	2-10-1-	L4-3-1-
400....	3814.20	3814.21	*Gd*	(^{2}) 1	0	10	6

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
800....	3814.67	3814.70	*Ti-Fe-C*	(2) 8	6	2-2-	L5-1-
900....	3815.96	3815.99	*Fe*	15	10	20	10
400....	3816.47	3816.49	*Fe-Co*	3	0	2-3	1-3
500....	3817.09	3817.06	*Co*	1	1	3	L4
750....	3817.79	3817.79	*Zr-C*	3	2	...	6-
750....	3818.45	3818.43	*Y-V-C*	(2) 2	1	5-4-	10-3-
750....	3819.29	3819.32	*C*	(3) 3	2d	...	...
6000....	3819.77	(3819.75)	*He*	...	4	...	...
1200....	3820.57	3820.59	*Fe*	25	10	50	10
500....	3821.30	3821.33	*Fe*	4	0	3	3
700....	3821.93	3821.96	*Fe-C*	5	2	2	2
500....	3822.46	3822.44	*C*	(2) 1	0	...	...
700....	3822.95	3823.00	*V-C*	1d?	1	2	2
600....	3824.13	3824.13	*Mn-Ce-C*	(3) 2	1	4-2-	4-3-
1000....	3824.60	3824.59	*Fe*	6	8	20	5
700....	{3825.46	3825.41	*C*	(2) 1	2	...	...
1000....	{3826.00	3826.03	*Fe*	20	8	20	5
500....	3826.37	3826.39	*C*	(2) 1	1	...	...
500....	3826.74	3826.76	–	1N	0	...	...
800....	3827.45	3827.46	*C*∸	(2) 2	1	...	...
800....	3827.93	3827.98	*Fe*	8	5	20	7
6000....	3829.49	3829.50	*Mg*	10	20	30	200
800....	{3830.71	{3830.74	*Er-C*	0	3	10	6
800....	{3831.20	{3831.17	*C*	3d	3	...	...
6000....	3832.48	3832.45	*Mg*	15	30	50	300
500....	3833.25	3833.22	*C*–	1	1	...	...
750....	3833.87	3833.83	*C*	(3) 1	2	...	...
7000....	3835.69	(3835.53)	*Hη*	...	55	...	...
750....	3836.22	3836.23	*Ti*	2	1	2	L4
1500....	3836.83	{3836.66	*C*	2	} 4	{ ...	...
		{3836.90	*Zr*	1		...	20
7000....	3838.44	3838.44	*Mg*	25	40	100	500
500....	3839.28	3839.28	*C*	1	1	...	...
600....	3839.75	3839.81	*Fe-Mn-C*	(4) 5	2	–2–	L3-3-
500....	3840.08	3840.11	*C*	(2) 1	1	...	...
2000....	3840.58	3840.58	*Fe-C*	8	5	15	4
800....	3840.88	3840.89	*V, La*	1	1	4, 3	2, 5
2000....	3841.21	3841.20	*Fe-Mn*	10	5	15-5	5-6
700....	3842.02	3842.04	*Co-C*	(4) 6	2	8–	10–
800....	3843.27	3843.24	*Zr-Fe-C*	(4) 10	3d	–3	L8-2
500....	3844.14	3844.14	*Mn-C*	2	1	3–	4–
600....	3844.43	3844.41	*C-V*	(2) 4	2	–4	–3
600....	3845.28	3845.29	*C-Fe*	(3) 5	1	–1	–1
800....	3845.58	3845.61	*Co-C*	8d?	3	20	30
600....	3846.40	3846.36	*Fe-C*	(3) 5	1	1–	L2–
750....	3846.93	3846.92	*Fe-C*	(4) 8	2	2–	2–
750....	3848.06	3848.03	*C*	(3) 3	2	...	...
500....	3849.07	3849.10	*La-C*	(2) 4	1	5–	10–
500....	3849.59	3849.59	*Ni-Zr*	(2) 2	1	–3	L3-3
800....	3850.07	3850.12	*Fe*	10	4	8	4
700....	3850.76	3850.78	*C*	0	1	...	...

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
700....	3851.36	3851.43	*C*	2Nd?	1	...	...
600....	3851.74	3851.74	*C*	$^{(3)}$ 1	1	...	...
800....	3852.64	3852.61	*Fe-Gd-C*	$^{(3)}$ 7	2	2-10-	2-8-
750....	3853.53	3853.52	*C*	$^{(2)}$ 3	2	...	...
750....	3854.15	3854.12	*C*	$^{(2)}$ 1	1	...	...
800....	3854.59	3854.61	*C-Ce*	$^{(2)}$ 4	3	-3	-3
800....	3854.95	3854.99	*C**	1	3	...	...
750....	3855.72	3855.75	*C-Fe*	$^{(2)}$ 5	2	...	...
6000....	3856.40	3856.46	*Fe-Si*	$^{(2)}$ 9	10	15-	5-5
750....	3856.98	3856.91	*C*	$^{(2)}$ 3	1	...	...
750....	3858.18	3858.22	*Ni-Cr-C*	$^{(2)}$ 13	2	20-3-	8-2-
750....	3858.86	3858.82	*C*	2N	2	...	...
6000....	3860.01	3860.05	*Fe-C*	20	20	20	6
750....	3860.74	3860.77	*C-Ni*	3N	1	...	...
750....	3861.62	3861.66	*C*†	$^{(4)}$ 8	3N	...	...
750....	3862.63	3862.63	*C*	2	2	...	...
750....	3863.56	3863.53	*C-Nd*	3N	2	-10	-8
750....	3864.50	3864.48	*C*	$^{(2)}$ 4	1	...	...
600....	3865.01	3865.00	*V*	3Nd?	1	5	3
900....	3865.26	3865.28	*C*	3	2	...	...
900....	3865.65	3865.67	*Fe-Cr*	7	2	8-1	4-L7
750....	3866.14	3866.12	...	3Nd?	1	...	...
900....	3866.93	3866.96	*C-V*	2	1	-2	-L3
750....	3867.34	3867.36	*Fe-C*	3	1	2-	2-
750....	3867.76	3867.76	*C-V*	1	2	-1	-2
500....	3868.08	3868.06	*Fe-C*	2	1	...	1-
500....	3868.52	3868.54	*C-Ti*	1	1	-4	-1
500....	3868.89	3868.87	*C*	1	1	...	...
500....	3869.27	3869.30	*C*	1	1	...	...
500....	3869.65	3869.69	*Fe-C*	3	2	1-	1-
500....	3870.03	3870.05	*C-Co*	1N	1	...	...
750....	3871.23	3871.24	*C*	$^{(4)}$ 3	2	...	...
750....	3871.51	3871.53	*C*‡	2d?	4	...	...
500....	3871.94	3871.96	*Fe, La*	2	1	2, 6	L4, 20
700....	3872.45	3872.40	*C*	1N	1	...	...
700....	3872.87	3872.86	*C*	1N	1	...	...
900....	3873.19	3873.18	*C-Co*	$^{(3)}$ 6	2	-10	-15
900....	3873.69	3873.71	*C*	1	1	...	...
900....	3874.04	3874.00	*Co-Fe-C*	$^{(2)}$ 8	2	10-2-	15-2-
500....	3874.89	3874.89	*C-*	$^{(2)}$ 3	1	...	...
500....	3875.33	3875.32	*Ti-V-C*	$^{(2)}$ 4	1	5-5-	2-2-
600....	3875.92	3875.92	*C-Nd*	2	2	...	-8
500....	3876.49	3876.50	*C*	$^{(2)}$ 1	1	...	...
600....	3877.06	3877.05	*Co-C*	$^{(2)}$ 8	1	5-	5-
500....	3877.45	3877.48	*C*	1	0	...	...
1200....	3878.79	3878.77	*Fe-V-Co*	$^{(3)}$ 11	15	15-1-	5-L10-L2
600....	3879.73	3879.72	*C-Nd*	1	1	-4	-3

* Fourth edge of cyanogen band.

† Third edge of cyanogen band.

‡ Second edge of cyanogen band.

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
600....	3880.33	3880.31	*C*	(5) 3	2	...	...
600....	3880.82	3880.82	*C*	1	1	...	...
600....	3881.39	3881.36	*C*	(5) 5	2	...	...
700....	3882.05	3882.01	*C-Co*	2	1	...	...
750....	3882.39	3882.44	*C*	2	2	...	...
750....	3882.64	3882.65	*C*	1	3	...	...
900....	3883.43	3883.46	*C**	(2) 3	5	...	...
500....	3883.81	3883.78	*Cr*	0	1	...	1
500....	3884.46	3884.50	*Fe*–	(2) 3	1	1	1
500....	3885.24	3885.29	*Fe*	2	0	...	...
1600....	3886.46	3886.43	*Fe-La*	15	15	20-5	5-15
600....	3887.16	3887.20	*Fe*	7	2	10	3
8500....	3889.47	(3889.20)	*Hζ*	...	60	...	...
500....	3890.55	3890.54	*Zr*	2	1	10	4
800....	3890.99	3890.99	*Fe*	3	2	1	1
600....	3891.55	3891.50	*Zr-V-Nd*	(3) 2	1	10-4-3	3-2-3
600....	3892.07	3892.04	*Ba-Fe*	(2) 5	2	50–	500-1
500....	3892.70	3892.70	*Mn*	2	1	1	1
800....	3893.16	3893.10	*V-Fe*	(3) 4	1	4-1	2-1
600....	3893.52	3893.54	*Fe*	4	1	2	2
1000....	3894.26	3894.21	*Co-Cr*-	(2) 8	2	15-3	30-3
500....	3894.65	3894.63	–	1N	0	...	...
500....	3895.20	3895.22	*Co-Ce-Ti*	(3) 6	1	4-3-4	5-2-2
1200....	3895.82	3895.80	*Fe*	7	4	10	3
650....	3896.34	3896.31	*Er-V*	(2) 0	1	15-3	6-3
500....	3896.84	3896.84	*Zr-Ce*	(2) 1	0	3-3	2-3
800....	3897.89	3897.85	*Fe-Zr*	(4) 6	2	3-2	3-2
500....	3898.52	3898.53	*Mn*	2	1	1	2
1000....	3899.23	3899.21	*V-Fe*	(2) 5	3	3-1	L6-1
1000....	3899.84	3899.85	*Fe*	8	3	10	4
1600....	3900.71	3900.68	*Ti*	5	10	5	L50
600....	3901.86	3901.90	*Nd*–	(2) 5	2	5	5
900....	3902.90	3902.89	*Fe-V-Er-Gd*	(4) 16	3d	10-4-10-5	5-2-5-4
1000....	3903.33	3903.37	*V-Cr*	(2) 3	4	4-2	L6-3
700....	3903.95	3904.02	*Fe-Er*-	(2) 8	1	–2	1-3
600....	3904.91	3904.93	*Ti*	3	1	10	5
500....	3905.27	3905.33	–	2	0	...	...
800....	3905.67	3905.66	*Si, Cr*	12	3	15, –	5, L6
600....	3906.03	3906.04	*Nd-Fe*	3	1	4–	4–
750....	3906.62	3906.63	*Fe*	10	2	8	3
500....	3906.86	3906.89	*V*	4	2	3	2
500....	3907.13	3907.10	*Ce*	1	1	2	1
750....	3907.59	3907.62	*Sc*	3d?	2	30	6
600....	3908.05	3908.08	*Fe-Nd*	5	2	1-4	1-3
600....	3908.63	3908.61	*V-Er*	(2) 1	2	2-2	1-2
500....	3909.79	3909.80	*Fe-V*	4	1	1-2	1-2
500....	3910.36	3910.08	*Ba-Co*	3Nd?	1	50-5	10-4
		3910.47	–	2		...	...
500....	3910.82	3910.88	*Fe-V*	(2) 6	1	1-2	1-2

* Head of cyanogen band.

TABLE I—*Continued*

HEIGHT OF CHROMOSPHERE	WAVE-LENGTHS		SUBSTANCE	INTENSITIES			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
500...	3911.29	3911.32	*Nd*	0	1	8	8
750...	3911.98	3911.96	*Sc*	2	1	30	6
750...	3912.32	3912.34	*V-Nd*	0	2	4-3	2-3
2000...	3913.69	3913.61	*Ti*	5d?	20	5	L20
750...	3914.60	3914.57	*V-Zr*	1	4	5–	L8-4
500...	3915.47	3915.49	*Fe, Cr*	(^{2}) 2	1	...	...
800...	3916.10	3916.12	*Zr-La*	(^{2}) 1	3	1-5	10-10
750...	3916.67	3916.68	*V-Cr-Fe-Gd*	(^{3}) 10	2	2-3-1-10	L8-2-2-8
500...	3917.39	3917.32	*Fe*	5	0	3	2
750...	3918.33	3918.31	*Ce-Mn*	(^{2}) 1	2	3-2	3-3
600...	3919.03	3919.04	*Fe-Cr*	(^{3}) 11	1	3-8	2-5
500...	3919.96	3919.96	*Ce-Cr*	0	0	3-1	3–
1000...	3920.39	3920.41	*Fe*	10	6	10	4
600...	3921.25	3921.19	*Cr*	3	1	5	3
600...	3921.73	3921.75	*La-Ti-Zr-Ce*	(^{3}) 9	1	5-5-5-3	10-2-3-3
500...	3922.60	3922.56	*V*	1	1	5	3
1200...	3923.06	3923.05	*Fe*	12d	8	10	15
400...	3924.22	3924.21	*Mn*	1	1	2	2
500...	3925.01	3925.01	*Ti, V*	(^{2}) 8	1	8, 9	3, 5
500...	3925.75	3925.79	*Fe*	5	1	2	1
600...	3926.12	3926.12	*Fe–*	(^{2}) 7	1	2–	1–
500...	3926.99	3927.01	*Cr–*	(^{3}) 1	1	...	...
1000...	3928.10	3928.08	*Fe-V*	8	10	15-4	4-3
500...	3929.30	3929.31	*La-Fe*	(^{2}) 4	1	6–	15–
1000...	3930.39	3930.45	*Fe*	8	8	15	4
500...	3931.29	3931.27	*V-Ce-Fe*	(^{3}) 2	1	4-3-1	3-2-
500...	3931.87	....	...	...	1	...	...
14000...	3934.10	3933.82K	*Ca*	1000	100	500	1000
750...	3935.03	(3934.98)	*Zr-Nd-Gd*	...	1	1-4-6	4-3-2
750...	3936.38	(3936.34)	*Zr-La*	...	1	–2	3-3
900...	3938.49	3938.51	*Cr*	(^{2}) 6	6?*	2	1–
600...	3939.57	....	...	...	1	...	...
600...	3940.31	....	...	...	1	...	...
600...	3941.01	3941.02	*Fe, Co*	5	1	2, 5	1-4
600...	3941.44	3941.42	*Fe, V*	3	1	1, 2	–, 2
600...	3942.12	3942.49 group	*Ce-V-Zr*	(^{6}) 7	1	8-2-1	9-2-4
600...	3942.89						
2000...	3944.17	3944.16	*Al*	15	15	800	15
600...	3944.85	3944.86	*Y-Dy*	(^{2}) 3	3	–10	L1-10
600...	3945.33	3945.36	*Co-Fe*	(^{3}) 7	3	6-1	5-1
400...	3946.57	3946.60	–	(^{4}) 2	1	...	...
600...	3947.88	3947.92	*Ti*	2	2	10	3
600...	3948.27	3948.25	*Fe-Er-Sa*	5	1	2-3-3	1-1-3
600...	3948.80	3948.82	*Ti*	4	2	12	4
750...	3949.21	3949.20	*La*	1	4	20	50
500...	3950.10	3950.10	*Fe*	5	2	3	2
750...	3950.47	3950.50	*Y*	2	4	20	L20
500...	3951.34	3951.32	*Nd-Fe*	5	2	10-2	8-2

* Coincides with ghost of K.

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
600...	3952.11	3952.10	*V*	2	2	2	L15
600...	3952.80	3952.80	*Ce-Fe*	(2) 7	2	8-2	7-2
600...	3953.17	3953.16	*Co-Mn*	(4) 10	2	8-2	6-3
400...	3954.67	3954.68	*Ni-Mn*	2	0	−1	1−
400...	3955.51	3955.48	*Fe*	5	0	1	...
800...	3956.53	3956.54	*Ti-Ce-Fe*	(2) 8	6d	15-3-2	4-3-2
400...	3957.19	3957.18	*Ca-Fe*	7d?	0	10-1	2-1
800...	3958.37	3958.36	*Zr, Ti*	5	8	3, 15	L20, 5
550...	3959.62	3959.63	*Gd*−	(2) 0	1N	6	6
400...	3960.47	3960.42	*Fe*	4	0	...	...
1500...	3961.65	3961.67	*Al*	20	20	1000	100
600...	3964.63	3964.65	*Ti-Fe*	(2) 5	1	8-1	3−
1000...	3964.86	(3964.88)	*He*	...	4	...	...
500...	3965.65	3965.66	−	2	0	...	...
500...	3966.72	3966.76	*Fe-Zr*	(3) 6	0	3-5	2-3
14000...	3968.92	3968.62H	*Ca*	700	80	300	500
8500...	3970.48	3970.18H_ϵ	H_ϵ	5	60	...	...
400...	3971.70	....	...	...	0	...	...
700...	3972.03	3972.05	*Eu-Gd*	(2) 1	1	50-4	50-3
700...	3972.41	3972.40	*Ni-Nd*	(3) 4	2	−2	1-2
750...	3973.74	3973.70	*Zr*	3	5	10	3
500...	3974.70	3974.76	*Co-Er-Ni*	(4) 13	1	4-15-2	4-5-
500...	3976.85	3976.84	*Cr*	3	2	6	8
500...	3977.33	3977.34	*Co*	0	0	...	L3
700...	3977.91	3977.89	*Fe-V*	6	2	3−	2-4
500...	3978.74	3978.73	*Co, Ce*	(2) 5	0	3, 3	3, 3
700...	3979.63	3979.66	*Cr-Nd-Co*	4	2	-5-4	L5-4-4
400...	3981.11	3981.12	*Ce-Nd*	1	0	2-1	3-3
700...	3981.95	3981.92	*Ti*	4	4	15	3
800...	3982.69	3982.70	*Y-Ti*	(2) 5	6	20-8	L20-3
400...	3983.31	3983.34	*Ce-Er*	2N	0	2-2	3-3
600...	3983.81	3983.81	*Dy*	∞	1	10	4
650...	3984.20	3984.17	*Fe-Mn*	(2) 6	2	2-1	2-1
400...	3984.78	3984.81	*Zr-Ce*	2	0	3-3	3-3
400...	3985.50	3985.52	*Fe-Mn*	(2) 4	1	1-2	1-3
500...	3986.32	3986.32	*Fe-Nd*	3	2	1-4	1-4
500...	3986.87	3986.90	*Mn-Zr*	6	2	2-1	4-1
500...	3987.29	3987.24	*Co-Mn*	(3) 5	1	1-2	L3-4
600...	3987.70	3987.75	*Ti*	2	1	...	L1
500...	3988.61	3988.66	*La*	0	6	15	30
400...	3989.23	3989.23	−	2	0	...	...
600...	3989.91	3989.91	*Ti*	4	3	20	4
600...	3990.26	3990.24	*Cr-Nd-Co*	(3) 2	2	3-8-3	3-6-3
700...	3991.30	3991.33	*Zr-Cr*	3	5	3-5	20-4
500...	3991.79	3991.80	*Co-Cr*	(2) 3	2	3-3	8-2
400...	3992.43	3992.40	−	2	1	...	...
400...	3993.00	3992.97	*V-Cr*	3d?	1	10-3	6-3
400...	3993.27	3993.25	*Fe*	2	0	...	...
400...	3993.94	3993.93	*Ti-Ce*	0	1	1-3	−4
500...	3994.82	3994.83	*Nd*	2	2	8	5
550...	3995.45	3995.46	*Co*	5	3	20	20

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
550....	3995.91	3995.90	*La*	1Nd?	3	10	5
350....	3996.71	3996.68	*Sc*	00	0	15	3
500....	3997.10	3997.12	*Fe*	2	1	...	1
600....	3997.55	3997.55	*Fe*	4	2	4	3
500....	3998.11	3998.13	*Co-Fe*	(^{2}) 8	2d	10-2	10-2
800....	3998.88	3998.85	*Ti-Zr*	(^{2}) 5	4	20-4	4-20
800....	3999.35	3999.39	*V-Ce*	0	8	-5	L3-6
550....	4000.52	4000.51	*Fe-Y-Dy*	(^{2}) 4	3d	-1-20	-1-15
500....	4001.29	4001.32	*Mn-Gd*	3	1	1-3	1-2
500....	4001.79	4001.81	*Fe-Ce*	3	2	1-4	1-4
400....	4002.48	4002.44	*Fe-Ti*	(^{4}) 3	0	...	...
400....	4003.05	4003.08	*V*	2	1	1	5
500....	4003.95	4003.91	*Ti-Ce*	3	2	2-3	2-4
400....	4004.58	4004.64	–	(^{2}) 0	0	...	...
500....	{4005.09	{4005.07	*Gd-Fe*	(^{3}) 3	1	3-	3-
800....	{4005.42	{4005.41	*Fe*	7	6	15	6
800....	{4005.88	{4005.86	*V*	3	6	2	L20
500....	4006.43	4006.46	*Fe*	2	1	1	1
500....	4006.88	4006.83	*Fe–*	(^{2}) 5	2	1	1
400....	4007.12	4007.14	*V-Mn*	1	0	1-3	-1
600....	4007.48	4007.43	*Fe*	3	2	1	1
350....	4008.14	4008.14	*Ti-Er*	(^{2}) 1	0	2-10	1-4
600....	4008.95	4009.05	*Ti-Gd-Pr*	(^{3}) 6	2	10-3-15	4-3-8
1000....	4009.46	(4009.42)	*He*	...	0	...	...
800....	4009.87	4009.86	*Fe-V*	3	2	2-2	2-1
500....	4010.58	4010.63	*Ce–*	(^{2}) 4	0	1-	2-
350....	4011.33	4011.31	*Fe*	(^{3}) 7	2d	...	...
800....	4012.55	4012.56	*Ti-Cr*	(^{2}) 4	15	1-2	L5-L6
400....	4012.93	4012.94	*Ti-Nd*	00	0	1-3	-2
600....	4013.90	4013.90	*Ti-Fe*	(^{2}) 8	1d	3-1	1-
800....	4014.67	4014.68	*Sc-Fe*	5d?	3	6-2	8-2
400....	4015.08	4015.09	*Ce*	0Nd?	0	3	4
500....	4015.69	4015.71	*Ni-Er-La*	(^{2}) 4	1d	-6-3	L2-3-1
400....	4017.33	4017.31	*V-Fe*	4	1	-1	L3-1
400....	{4017.95	{4017.92	*Ti*	0	} 0	{ 4	2
		{4018.25	*Mn*	7	}	{ 10	8
500....	{4018.42	{4018.42	*Fe*	3	} 2	{ 1	1
500....	4019.18	4019.20	*V-Ce*	1	1	1-1	3-2
400....	4019.46	4019.45	*Co*	0	0	2	2
400....	4020.20	4020.23	*Mn*	1	0	1	1
500....	4020.58	4020.55	*Sc*	1	2	20	8
500....	4021.02	4021.06	*Co-Nd*	3	2	8-4	5-4
600....	4021.55	4021.49	*Nd*	0	2	4	4
700....	4022.05	4022.02	*Ti-Fe*	5	4	4-2	2-2
350....	4022.47	4022.50	*Gd-Ce-Fe*	(^{2}) 1	0	3-2-	3-2-
500....	4023.16	4023.16	*Nd*	0	1	5	5
750....	4023.56	4023.53	*V-Co*	3	4	2-2	L20-L3
750....	4023.80	4023.83	*Sc*	2	2	30	8
500....	4024.20	4024.21	*Zr-Fe*	(^{2}) 3	0	5-	3-
750....	4024.75	4024.73	*Ti*	3	3	10	3
750....	4025.28	4025.29	*Ti-Ce*	3	3	1-2	L3-2

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
6000....	4026.47	(4026.34)	*He*	...	20	...	...
400....	4027.35	4027.40	*Zr*	00	0	5	3
500....	4027.81	4027.82	*Ce*	1	1	1	3
450....	4028.10	4028.09	–	0	0	...	...
750....	4028.50	4028.50	*Ti-Ce*	4	6	1-4	L6-4
350....	4029.12	4029.14	*Zr*	000	0	4	2
500....	4029.74	4029.80	*Zr-Fe*	5	2	4-1	2-1
700....	4030.62	4030.65	*Ti-Nd*	5	4	8-4	2-4
750....	4030.93	4030.92	*Mn*	9	12	100	20
500....	4031.40	4031.43	*V-Ce*	(²) 2	1	2-4	2-4
600....	{4031.83	{4031.86	*La*	2	} 2	{ 5	20
		4031.94	*Nd-Mn*	2		8-2	10-3
400....	4032.14	4032.12	*Fe*	2	0	1	1
750....	4032.75	4032.73	*Fe-Dy*	(²) 6	2	1-4	1-4
750....	4033.21	4033.22	*Mn*	8d?	9	100	20
750....	4034.61	4034.64	*Mn-Fe*	6d	8	50-2	10-
750....	{4035.70	{4035.75	*V-Co*	2	} 3	{ 2-8	L20-3
		4035.88	*Mn*	4		5	8
750....	4036.08	4036.05	*Zr, Ti*	(²) 1	3	5, 3	3, 2
400....	4036.57	4036.52	–	0	0	...	...
350....	4036.96	4036.92	*V*	1	0	1	4
400....	4037.46	4037.45	*Gd*	00	1	10	6
350....	4038.70	4038.74	*Fe, Mn*–	(⁴) 4	0	...	...
350....	4039.75	4039.73	*V-Gd*	0	0	1-3	3-2
350....	4040.16	4040.19	*V-Fe*	(²) 3	0	1-1	...
600....	4040.96	4040.94	*Ce-Nd*	1d?	5	6-5	8-4
600....	4041.52	4041.52	*Mn-Fe-Zr*	(³) 9	2d	20-1-2	10-1-1
300....	4042.20	....	...	...	0	...	...
600....	4042.76	4042.74	*Ce-V*	0	2	5-3	5-3
600....	4043.01	4043.05	*La*	0	4	5	20
500....	{4043.86	{4043.84	*Ti*	0	1	1	1
500....	4044.12	4044.09	*Fe*–	(²) 5	1	1	1
500....	4044.78	4044.77	*Zr-Fe*	3	1d?	5-1	3-1
500....	4045.51	4045.54	*Co-Er*	5	2	8-3	5-2
1000....	4045.98	4045.98	*Fe*	30	15	50	15
400....	4046.56	4046.55	*V-Ce*	(²) 1	0	–3	4-4
600....	4047.12	4047.17	–	00N	1	...	...
300....	4047.48	4047.46	*V-Fe*	2	0	1–	1–
400....	4047.82	4047.82	*Y*	0N	0	8	4
400....	4048.23	4048.22	–	1N	1	...	...
600....	4048.88	4048.88	*Zr-Mn-Fe*	6d	5d	4-8-2	10-7-L4
500....	4049.60	4049.59	*Fe-Gd-Cr*	(³) 4	1	–8–	–4–
500....	4049.95	4050.02	*Gd*	00	0	10	6
500....	4050.46	4050.48	*Zr*	0	2	2	8
300....	4051.05	4051.10	–	00	0	...	...
500....	4052.24	4052.22	*Cr, Fe*	(²) 5	1	–, –	L3, –
500....	4052.62	4052.63	*Mn-Fe*	(²) 5	1	2–	3–
700....	4053.48	4053.42	*V-Gd*	2	1	2-5	2-5
750....	4053.98	4053.98	*Ti-Fe*	3	3	1–	L5–
500....	{4054.67	{4054.71	*Sc*	00N	1	10	3
500....	4054.97	4055.00	*Fe*	(²) 5	2	2	2
500....	4055.22	4055.19	*Ti-Zr*	3	1	4-5	3-3

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths: Chromo-sphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromo-sphere	Intensities: Arc	Intensities: Spark
km							
600....	4055.82	4055.70	*Mn-Fe*	6	1	4-2	8-L3
		4055.86	*Zr*	00		4	3
400....	4056.30	4056.28	*V, Cr*	(^{2}) 1	0	1, 1	1, 2
400....	4056.69	4056.65	*Sc-Zr*	(^{2}) 1	0	3-1	-1
400....	4057.24	4057.22	*V*	0	1	5	3
500....	4057.63	4057.67	–	7	2	...	...
450....	4058.32	4058.37	*Co-Ti-Gd*	4	1	4-2-4	3-2-3
500....	4059.07	4059.08	*Mn*	3	2	4	6
450....	4059.58	4059.54	*Mn-Gd*	1Nd?	0	3-2	2-3
450....	4059.88	4059.87	*Er-Fe*	2	1	10–	4–
450....	4060.47	4060.42	*Ti*	1	1	5	3
700....	4061.20	4061.24	*Nd*	3	3	10	10
400....	4062.28	4062.28	*Ce–*	(^{2}) 0	0	2–	4–
600....	4062.65	4062.63	*Fe-Gd*	(^{2}) 5	2	2-4	2-6
400....	4062.99	4063.00	*Cu–*	(^{2}) 0	0	100–	10–
900....	4063.70	4063.70	*Fe*	(^{2}) 24	12	30	10
400....	4064.77	4064.73	–	00	1	...	...
500....	4065.46	4065.42	*V-Ti*	(^{2}) 5	2	2-4	L6-3
500....	4066.64	4066.63	*Co-Fe*	(^{2}) 4	2	5-1	5–
500....	4067.21	4067.25	*Ni-Fe*	(^{2}) 8	4	-4	L5-2
500....	4067.57	4067.56	*La*	000	0	4	8
450....	4068.15	4068.14	*Fe-Mn*	6	1	2-2	1-2
450....	4068.77	4068.79	*Co-Ce*	(^{2}) 1	2	4-5	5-5
450....	4069.34	4069.29	*Nd-Ti*	(^{2}) 2	2	4-1	4-1
400....	4069.75	4069.76	–	1	0	...	...
400....	4070.44	4070.43	*Mn-Gd*	3	1	4-10	3-5
400....	4071.05	4071.00	*Cr-Fe*	(^{3}) 5	1d	-1	L4-1
900....	4071.90	4071.91	*Fe*	15	10	20	8
400....	4072.50	4072.53	*Fe-V*	(^{3}) 3	0	...	...
400....	4073.27	4073.29	*Gd*	0	0	4	4
500....	4073.55	4073.64	*Ce*	0	1	3	4
500....	4073.89	4073.92	*Gd-Fe*	4	3	10-1	8-1
350....	4074.45	4074.49	*Ti-Nd*	0N	0	-2	1-1
500....	4075.12	4075.07	*Nd-Fe*	(^{2}) 5	2d	6-1	4-1
400....	4075.82	4075.86	*Ce*	0	1	3	3
500....	4076.22	4076.17	*Cr-Ce-Fe*	(^{2}) 4	2	4-3-	1-3-
400....	4076.66	4076.64	*Fe-Zr*	2	0	3-3	2-1
6000....	4077.98	4077.88	*Sr*	8	40	1000	L1000
500....	4078.64	4078.63	*Ti*	3	3	8	4
500....	4079.26	4079.33	*Fe-La*	2	1	-2	-1
600....	4079.81	4079.78	*Mn-Fe*	(^{2}) 6	2	3–	5–
500....	4080.47	4080.37	*Fe, Nd*	3	1	1, 3	–, 2
500....	4081.36	4081.38	*Zr-Ce-Er*	0	2	10-4-8	5-4-3
350....	4082.37	4082.31	*Fe-Zr*	2	0	-2	-2
400....	4082.58	4082.59	*Sc-Cr-Ti*	3	1	15-5-	3-3-L2
350....	4082.79	4082.75	*Co*	0	0	2	2
400....	4083.18	4083.14	*Mn-Ce*	(^{2}) 5	0	4-3	6-5
500....	4083.62						
400....	4083.97	4083.92	*Y-Fe*	1	1	8–	3–
400....	4084.24	4084.31	*Zr–*	(^{2}) 1	0	2–	2–
400....	4084.64	4084.65	*Fe*	5	1	2	1

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
500....	4085.32	4085.32	*Fe-Ce*	(3) 9	3	3-3	1-3
450....	4086.44	4086.47	*Co*	3d?	2	10	8
500....	4086.79	4086.86	*La*	1	4	10	20
400....	4087.22	4087.25	*Sc-Fe*	3	1	3-1	...
450....	4088.71	4088.71	*Nd-Ce*	3	2	2-1	1–
400....	4089.37	4089.37	*Fe*	3	1	...	...
400....	4090.05	4090.11	*Mn*	0Nd?	1	2	2
500....	4090.72	4090.71	*V-Zr*	(2) 1	2	10-3	10-4
400....	4091.12	4091.11	*Ce*	3	1	2	2
400....	4091.69	4091.71	*Fe*	3	1	...	...
500....	4092.56	4092.55	*Co-Mn*	3	3	8-1	10-2
500....	4092.87	4092.82	*V-Ca*	3d?	3	15-4	3-1
400....	4094.51	4094.57	*Gd*	2N	0	4	3
400....	4095.05	4095.09	*Ca*	4	1	6	2
500....	4096.17	4096.20	*Fe-Nd*	(2) 5	2	–3	1-3
500....	4096.94*	....	...	...	2	...	...
500....	4097.96	4097.96	–	(3) 1	0	...	...
500....	4098.33	4098.34	*Fe-Nd*	5	3	1-3	1-3
500....	4098.98	4098.95	*Gd-Ca*	000	2	15-10	6-2
500....	4099.95	4099.94	*V*	2	1	20	10
8000....	4102.00	4102.00	H_δ	40N	70	...	...
500....	4103.10	4103.10	*Si, Mn*	5	1	1, 1	1, 2
400....	4103.65	4103.62	–	(2) 1	0	...	...
450....	4104.27	4104.29	*Fe*	5	2	1	1
400....	4104.65	4104.62	*Co, V*	0	0	2, 3	1, 3
450....	4105.21	4105.24	*V-La*	(2) 3	3	10-3	5-1
450....	4106.49	4106.50	*Fe*	(2) 4	2d	...	...
450....	4107.64*	4107.65	*Ce-Fe-Zr*	5	2	3-3-3	4-2-2
400....	4108.69	4108.69	*Nh, Er*	2	0	10, 2	5, 1
600....	4109.37	4109.31	*Nd*	(2) 4	3	13	14
600....	4109.88	4109.90	*V*	2	3	15	10
500....	4110.63	4110.69	*Co*	4	2	10	10
450....	4111.62	(4111.57)	*Ce, Gd*	...	1	3, 4	3, 4
450....	4111.97	4111.94	*V*	4	2	30	4
400....	4112.45	4112.48	*V-Fe*	2	0	2–	2–
400....	4112.89	4112.87	*Ti*	1	0	5	2
400....	4113.24	4113.18	*Fe, Mn*	(2) 4	1	1, 1	–, 2
450....	4114.00	4114.02	*Nd-Sa*	00Nd?	2d	3-3	4-3
450....	4114.73	4114.77	*Fe-V*	(2) 6	3	2-2	1-2
450....	4115.35	4115.33	*V*	3	3	5	6
400....	4116.14	4116.14	*Ni*	0	1	1	1
450....	4116.78	4116.74	*V-Nd*	(3) 2	2d	15-4	5-4
500....	4118.02	4118.01	–	2	1	...	...
600....	4118.85	4118.85	*Co-Fe-V*	(3) 11	5N	10-4-3	20-3-3
350....	{4119.53	{4119.55	*V-Fe*	1	0	4–	3–
350....	{4119.74	{4119.75	–	(2) 1	...	...	...
350....	{4120.12	{4120.08	*Ti*	0	0	1	1
400....	4120.35	4120.37	*Fe*	4	1	1	1
1000....	4120.93	(4120.97)	*He*	...	2	...	...
500....	4121.46	4121.48	*Co*	6d?	3	20	20

* Coincides with ghost of H_δ.

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
350....	4122.02	4122.05	*Ti, Cr*	(2) 4	1d	3, 2	2, 2
500....	4122.80	4122.82	–	1	3	...	...
650....	4123.45	4123.44	*La-V*	(2) 2	5	10-7	30-5
500....	4123.93	4123.91	*Fe, Ce-Nd*	5	3	1, 4-4	1, 5-4
500....	4124.96	4124.94	*Ce*	0	2	3	4
400....	4125.93	4125.90	*Fe–*	(3) 7	1	...	...
400....	4126.35	4126.34	*Fe*	4	0	1	...
400....	4126.66	4126.67	*Cr*	2	1	3	3
550....	4127.86	4127.86	*Fe-Ce*	(2) 8	5	3-2	1-2
550....	4128.25	4128.25	*V*	6d	5	10	10
550....	4128.91	4128.89	*Nd*	2	0	1	2
400....	4129.41	4129.45	*Ce-Pr*	(2) 5	1	2-4	2-3
550....	4129.88	4129.88	*Eu*	1	5	100	100
450....	4130.83	4130.80	*Ba*	2	2	100	L800
400....	4131.46	4131.51	*Cr*	0	0	1	2
550....	{4132.05	{4132.10	*V*	2	2	10	10
550....	{4132.28	{4132.24	*Fe*	10	2	15	4
500....	4133.05	4133.06	*Fe-Sc*	4	1	2-4	2–
500....	4133.93	4133.91	*Fe-Ce*	(3) 5	2d	1-8	–10
400....	4134.49	4134.54	*V-Fe*	(2) 6	2	10-1	10–
500....	4134.84	4134.84	*Fe*	5	5	3	2
500....	4135.56	4135.53	*Nd, Ce*	(2) 1	2d?	8, 3	7, 3
400....	4136.02	4135.97	*Zr-Ce*	(2) 1	1	3-1	2-2
500....	{4136.69	4136.68	*Fe*	4	2	...	...
500....	{4137.21	4137.16	*Mn-Fe-Gd*	6	3	-2-5	L3-8
500....	4137.79	4137.81	*Ce*	1	4	4	10
400....	4138.31	4138.32	*V-Ce*	(2) 1	0	2-2	2-2
400....	4139.08	4139.01	–	0	1	...	...
350....	4139.57	....	...	0	...	...	...
400....	4140.24	4140.24	*Fe–*	(2) 9	1	1	...
400....	{4141.81	{4141.81	*La*	0	1	5	10
400....	{4142.03	{4142.02	*Fe*	4	1	...	...
400....	{4142.56	{4142.54	*Cr-Ce*	(4) 8	2	–3	–5
400....	4143.28	4143.21	*Er-Pr*	(2) 1	2	10-20	5-10
1000....	4144.05{	(4143.92)	*He*	...	}6d	{...	...
		4144.04	*Fe*	15		15	5
450....	4144.63	4144.67	*Ce-Nd*	0Nd?	2	3-3	3-2
450....	4145.13	4145.15	*Ce*	0	2	4	8
400....	4145.37	4145.36	*Co*	1	0	...	L3
400....	4145.84	4145.84	*Cr-V*	(2) 1	1	–1	L6–
400....	4146.23	4146.22	*Nd-Fe*	3	2	2–	3–
400....	4147.12	4147.14	–	2	0	...	...
400....	4147.69	4147.71	*Fe-Mn*	(3) 7	2	3-2	1-2
400....	4148.98	4148.95	*Mn*	0	1	2	3
600....	4149.37	4149.36	*Zr*	2	8	6	30
400....	4150.03	4150.06	*Ce*	00	2	10	10
400....	4150.40	4150.41	–	4	0	...	...
400....	4150.68	4150.64	*Ti-Co*	(2) 2	1	1–	1–
500....	4151.18	4151.13	*Zr-Ti-Ce*	1	3	3-3-3	6-3-3
500....	4152.23	4152.25	*La, Ce-Fe*	(3) 6	6N	6, 4-	10, 9
350....	4152.68*	4152.66	*Zr-Sc-C*	(3) 1	0	3-8-	2–

* Sixth edge of second cyanogen band.

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
400....	4153.51	4153.54	*Fe-Sa*	1	0	-4	-3
500....	4154.09	4154.11	*Fe-Cr-*	(3) 7	2d	4-3-	2-3-
500....	4154.67	4154.67	*Fe*	4	3	4	2
500....	4156.30	4156.34	*Zr-Nd-*	(4) 5	8	4-10-	10-10-
500....	4157.00	4156.97	*Fe*	3d?	3	4	2
400....	4158.00	4157.95	*Fe*	5	3	3	1
400....	4158.20	4158.17*	*C*	00	1	...	...
400....	4159.00	4158.96	*Fe*	5	2d?	2	1
350....	4159.40	4159.35	–	5	0	...	...
400....	4160.57	4160.59	*Co-Nd-*	(2) 3	0d	1-3-	L8-4-
400....	4161.23	4161.30	*Zr-*	(2) 4	1	4-	10-
600....	4161.65	4161.68	*Ti*	4	5	...	L3
400....	4162.79	4162.72	*Gd-Ce-*	(2) 2N	2d	4-1	3-2
650....	4163.82	4163.82	*Ti-Cr*	4	10	2-2	L20-4
400....	4164.45	4164.46	*C?*	(2) 1	1	...	...
350....	4164.88	4164.88	*Er-C*	(2) 1	0	2-	1-
400....	4165.33	4165.33	*Sc-C*	00	1	8-	...
500....	4165.73	4165.76	*Ce*	1	2	4	10
400....	4166.16	4166.16	*Ba*	0	0	10	100
400....	{4167.00	4167.01	*Ce*	0	1	3	5
1500....	{4167.60	{4167.44 4167.74†	– *Y-C*	8} 1}	3	10	4
400....	4168.09	4168.08	*C-Nd-Dy*	(2) 4	2d	2-2-20	3-3-4
400....	4168.91	4168.95	–	(2) 4	1d	...	...
1500....	4169.20	(4169.13)	*He*	...	0	...	...
400....	{4169.52	....	...	...	2	...	...
400....	4169.96	4169.93	*Ce*	2	2	5	5
350....	4170.52	4170.51	*Cr-Nd*	(3) 1	0	1-2	2-2
500....	4171.21	4171.21	*Ti*	4	3	3	2
600....	4172.15	4172.07	*Ti*	2	10d?	1	L15
600....	4172.83	4172.86	*Fe-*	(2) 6	1d	2-	1-
600....	4173.64	4173.67	*Ti-Fe*	(2) 6	10	-1	L3-L3
500....	4174.10	4174.12	*Ti-Fe*	(2) 4	1d	-1	L2-1
500....	4175.04	4175.06	*Fe-Cr*	(2) 4	2	3-3	1-3
500....	4175.80	4175.81	*Fe-Nd*	5	3	3-4	2-5
400....	4176.74	4176.74	*Fe-Mn-Ce*	5	1	2-2-2	1-4-3
700....	4177.70	4177.70	*Y-Fe*	3	12	15-2	L50-1
600....	4179.03	4179.02	*Fe*	3	8	...	L3
600....	4179.58	4179.54	*V-Pr*	3d?	3	5-20	3-10
400....	4180.51	4180.56	*C-*	1	1	...	...
400....	4180.98	4180.97‡	*C*	2N	2	...	...
600....	4181.97	4181.95	*Fe-*	(3) 8	3d	4	4
450....	4182.52	4182.55	*Fe*	3	2	1	1
350....	4182.90	4182.92	–	2	0	...	...
400....	4183.54	4183.57	*V-Zr*	(2) 3N	2d	1-3	L10-3
500....	4184.35	4184.32	*Ti-Gd-*	(3) 6	3d	-10	L1-10
500....	4185.05	4185.06	*Fe-Nd-C*	4	3	3-2-	2-4-
350....	4185.87	4185.89	*C-*	(2) 1	1	...	...

*Fifth edge of second cyanogen band.

†Fourth edge of second cyanogen band.

‡Third edge of second cyanogen band.

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
600....	4186.70	4186.78	*Ce-Zr*	2N	3	10–	10-4
600....	4187.24	4187.20	*Fe*	6	4	8	4
600....	4187.93	4187.91	*Fe-Ti-Ni*	(4) 10	4	10-5-1	4-3-L4
400....	4188.89	4188.89	*Ti-Nd*	4	2N	2-1	1-1
400....	4189.58	....	*C*	...	1	...	...
400....	4190.22	4190.22	*Er-Mn-C*	(2) 1	2	5-2-	4-4-
350....	4190.85	4190.87	*Co-Er-C*	1Nd?	0	5-5-	3-3-
550....	4191.63	4191.68	*Fe*	(2) 9	5d	5	3
350....	4192.20	4192.17	*Cr-C*	0	0	2–	2–
400....	4192.70	4192.73	*–C*	2N	0	...	...
400....	4193.11	4193.07	*C*	00	1	...	...
400....	4193.58	4193.58	*C*	(2) 0	2d	...	...
400....	4194.00	4193.96	*Ce-C*	0	1	2–	3–
350....	4194.60	4194.57	*C*	(4) 1	1N	...	...
450....	4195.12	4195.06	*Nd-Ce*	(2) 1	2	3-2	3-3
450....	4195.66	4195.67	*Fe-C*	(3) 8	2N	3-	1-
500....	4196.75	4196.70	*La*	2	2	10	10
500....	4197.27	4197.26*	*C*	2	3	...	...
400....	4197.80	4197.81	*C*	00	1	...	...
600....	4198.41	4198.40	*Fe–*	(3) 10	5d	5–	3–
600....	4198.85	4198.80	*Ce-Fe-C*	3	3	10-1-	6–
600....	4199.25	4199.27	*Zr-Fe*	5	5	6-6	5-3
500....	4200.10	4200.15	*Fe-Nd*	2	1	1-1	–2
500....	4200.83	4200.85	*Ti-Fe-C*	(5) 5	3N	2-1-	2–
400....	4201.90	4201.87	*Mn-Ni*	1	0	1-2	2–
600....	4202.29	4202.20	*Fe*	8	6	10	6
400....	4202.59	4202.57	*V-C*	0Nd?	0	2–	3–
500....	4203.15	4203.10	*Ce-Sa*	0N	3	5-10	5-6
400....	4203.75	4203.73	*Cr*	2	0	2	1
500....	4204.14	4204.14	*Fe-La*	(2) 7	2	3-4	2-4
400....	4204.84	4204.88	*Y*	1	0	5	L5
550....	4205.22	4205.21	*V-Eu*	(2) 2	8	1-100	L10-50
450....	4205.70	4205.70	*Nd*	2	1	4	4
400....	4206.44	4206.46	–	0	0	...	...
400....	4206.99	4207.03	*Fe-Pr*	(3) 7	2d	2-20	2-15
400....	4207.40	4207.36	*Fe-C*	(2) 4	1d	1–	1–
350....	4208.30	4208.27	*C*	00	0	...	...
350....	4208.75	4208.77	*Fe*	3	0	1	1
550....	4209.11	4209.14	*Zr*	1	4	4	L20
350....	4209.87	4209.84	*V-Cr-*	(3) 2	0	8-1-	9-1-
500....	4210.53	4210.52	*Fe-Sa*	(2) 7	3d	4-8	3-3
350....	4210.92	4210.86	*Zr-C*	000	0	...	3–
400....	4211.41	4211.46	*Nd-C*	(2) 1	0	4–	5–
500....	4212.04	4212.05	*Zr-C*	2	3	3–	5–
400....	4212.89	4212.84	*Cr-C*	(2) 3N	1	2–	2–
500....	4213.81	4213.81	*Fe-C*	3	3N	1–	1–
350....	4214.22	4214.20	*C*	00	0	...	...
6000....	4215.88	4215.87†	*Sr*	5d?	40	500	L500
400....	4216.32	4216.35	*Fe*	3d?	1	3	1

* Second edge of second cyanogen band.

† Edge of second cyanogen band at 4216.14.

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
500....	4217.28	4217.36	*Gd*	1	2	5	5
500....	4217.70	4217.72	*La-Cr*	5	2	4-3	10-2
400....	4218.52	4218.56	*Zr, Er*	1Nd	1	3, 8	2, 3
400....	4218.84	4218.88	*V*	3N	1	2	2
500....	4219.56	4219.54	*Fe-*	(2) 7	3	3-	3-
450....	4220.48	4220.51	*Fe*	3	2	1	1
450....	4220.78	4220.81	*Y-Sa*	00	2	10-8	1-4
500....	{4222.38	{4222.38	*Fe*	5	2	4	2
500....	4223.10	4223.11	*Ce-Pr-*	(5) 2	1	10-18	5-15
400....	4223.64	4223.69	–	(2) 2	1	...	...
450....	4224.35	4224.34	*Fe-V*	4	2	3-3	1-2
400....	4224.83	4224.81	*Cr*	(2) 5	1d	...	L4
500....	4225.45	4225.49	*V-Sa-Pr*	000	2	1-10-20	L6-4-15
5000....	4226.90	4226.90	*Ca*	20d?	25	1000	100
400....	4227.88	4227.92	*Zr-V-Ce-Nd*	0	2	10-2-3-3	4-3-4-3
350....	4228.34	(4228.35)	*Nd*	...	0	3	2
350....	4228.84	4228.88	–	1	1	...	...
400....	4229.87	4229.86	*Fe-V-Sa*	(3) 6	3d	1-2-10	-3-4
350....	4230.45	4230.41	*Er*	00Nd?	0	8	3
500....	4231.18	4231.18	*La-Ni*	4N	2	2-2	6-1
400....	4232.60	4232.64	*V-Nd*	(2) 0	1	5-5	5-5
1000....	4233.40	4233.33	*Fe-Cr*	4	20	...	L4-L2
400....	4233.82	4233.77	*Fe*	6	1	6	3
400....	4234.35	4234.38	*Nd, Ce*	0N	1	3, 2	4, 2
400....	4235.37	4235.39	*Mn-Nd*	(2) 5	3	10-4	20-4
400....	4235.98	4235.94	*V-Y*	(2) 1	1	4-10	5-L6
650....	4236.24	{4236.11	*Fe-Y*	8}	6	{10-10	4-5
		4236.28	*Zr*	1}		4	2
350....	4236.72	4236.71	*Zr*	00	0	3	...
450....	4237.24	4237.25	*Fe-Sa-*	(5) 6	2d	1-10	-5
500....	4238.15	4238.19	*Fe-Sc*	3	2	1-3	1-1
500....	4238.55	4238.56	*La*	1Nt?	2	20	10
500....	4239.02	4238.97	*Fe-Gd*	5	2	3-4	2-4
500....	4240.05	4239.99	*Fe-Ce-Nd*	(3) 7	3	2-5-4	1-5-4
400....	4240.68	4240.64	*Zr-Cr-Fe*	(3) 4	0d	8-2-1	3-2-
400....	4241.26	4241.28	*Zr-Pr*	2	1	4-10	-10
600....	4242.40	4242.45	*Cr-Mn-Er*	3	3N	...	L6-L4-L3
400....	4242.91	4242.90	*Cr-Fe*	2	1	3-	3-
500....	4243.32	4243.36	*Nd*	1d?	2	2	1
400....	4243.82	4243.75	*Fe-Zr-Gd*	(3)-6	1d	-1-2	-1-3
400....	4244.80	....	...	...	1N	...	...
500....	4245.44	4245.45	*Fe-*	(2) 6	2	2-	1-
400....	4246.22	4246.21	*Fe*	2	1	1	1
6000....	4247.07	4247.00	*Sc*	5	30	50	100
400....	4247.57	4247.59	*Fe, Nd*	4	1	3, 10	2, 8
500....	{4248.42	{4248.38	*Fe*	2	2	1	1
550....	4248.84	4248.88	*Ce*	2N	3N	4	6
400....	4249.68	4249.65	–	1N	1	...	...
700....	{4250.32	{4250.29	*Fe*	8	4	10	4
700....	4251.01	4250.96	*Fe*	(2) 9	5	15	6

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
500	4251.85	4251.84	*Mn-Gd*	(2) 0	2	–10	L5-10
500	4252.62	4252.70	*Cr-Nd*	(2) 1	3	–4	L3-7
350	4253.12	4253.15	–	(3) 3	0	...	...
400	4253.55	4253.52	*Ce, Gd*	∞	1	3, 5	2, 4
600	4254.52	4254.50	*Cr*	8	15	50	50
350	4255.46	4255.42	*Fe-Cr-V-Zr*	(4) 5	0	1-1-1-1	1-1-1-1
500	4256.05	4255.99	*Ce-Fe*	2N	1	3–	2–
500	4256.60	4256.58	*Zr-Sa*	∞	1	3-10	2-5
400	4257.49	4257.52	*V*	∞	0	3	3
400	4257.81	4257.82	*Mn*	2	1	3	4
400	4258.37	4258.34	*Zr-Fe*	(3) 3	4N	3–	L8–
400	4258.74	4258.77	*Fe, Ti*	2	1	1, 1	–, 1
400	4259.23	4259.26	*Mn-Fe-V*	(4) 4	1N	-1-3	L4-3-
500	4260.27	4260.23	*Fe*	(2) 5	2d	1	...
600	4260.67	4260.64	*Fe*	10	8	20	10
500	4261.58	4261.52	*Cr-Mn*	(3) 4	1	2-1	1-1
500	4261.98	4262.00	*Cr-Nd*	(3) 4	2	–3	5-4
400	4263.35	4263.32	*Ti-Cr*	(2) 3	1	8-3	4-3
400	4264.48	4264.52	*Fe–*	(4) 7	1d	1–	...
400	4265.36	4265.42	*Fe, V*	2	0	1-3	–3
400	4266.10	4266.08	*Mn*	2	1	3	5
500	4266.98	4267.03	*Fe-Nd*	(3) 4	1N	1-4	1-2
350	4267.55	4267.54	–	2	0	...	...
500	4267.92	4267.95	*Fe–*	(2) 4	3	2–	1–
400	4268.20	4268.20	*Zr–*	(2) 1	1	4	2
500	4268.77	4268.78	*V*	0	2	8	10
400	4269.68	4269.62	*La*	0	1	6	10
400	4269.83	4269.90	*V*	2	1	3	3
400	4270.35	4270.33	*Ti-Ce*	1N	1	3-3	2-3
800	4271.32	4271.32	*Fe*	6	4	15	4
800	4271.93	4271.93	*Fe*	15	10	30	10
350	4272.93	4272.88	*Nd-V*	(2) 2	1	4-1	2-1
600	4273.52	4273.55	*Zr-Fe*	(2) 5	3	3–	4–
400	4274.15	4274.21	–	(3) 4	0	...	...
800	4274.93	4274.96	*Cr*	7d?	20	50	30
500	4275.70	4275.76	*La-Ce*	(2) 1	2	3-2	4-1
450	4276.80	4276.84	*Zr-Er*	2	1	3-1	1-3
400	4277.15	4277.15	*V*	1N	1	5	8
400	4277.60	4277.65	*Zr–*	(2) 2	1	2–	2–
400	4278.36	4278.39	*Ti-Fe*	3	2	3-1	2-1
400	4278.92	4278.96	*Ti-Mn-Ce*	(2) 2	0N	2-1-2	1-1-2
450	4279.81	4279.76	*Sa–*	(2) 4	2	8	4
450	4280.14	4280.20	*La, Ti–*	(3) 3	1	4, 1–	1, 1–
450	4280.57	4280.56	*Cr*	1	1	3	3
450	4280.88	4280.86	*Sa, Gd*	(2) 2	1	8–	4-3
450	4281.23	4281.26	*Mn*	2	2	3	5
500	4282.10	4282.13	–	2N	2	...	...
700	4282.60	4282.56	*Fe*	5	5	10	3
700	4283.11	4283.17	*Ca*	4	3	50	20

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
500....	4284.30	4284.34	*Cr-V-Mn*	(2) 3	2N	-8-2	L3-10-2
400....	4284.96	4285.01	*Ti-Ni-Zr*	(3) 4	1	3-1-1	3-1-1
400....	4285.59	4285.61	*Fe-Ce*	(3) 5	2	1-2	1-3
400....	4286.04	4286.07	*Ti–*	(2) 3	2	10–	4–
500....	4286.58	4286.63	*V*	3N	1	2	3
400....	4287.05	4287.11	*La–*	(2) 3	1	6	20
600....	4288.11	4288.13	*Ti-V*	(3) 4	4N	3-2	3-3
500....	4288.85	4288.89	*Ce*	00N	1	3	2
500....	4289.25	4289.24	*Ti*	2	2	15	4
1300....	4289.78	4289.52	*Ca*	4	15	50	20
		4289.88	*Cr*	5		30	30
1300....	4290.33	4290.38	*Ti*	2	15	2	L10
500....	4291.30	4291.30	*Ti-Fe*	(5) 9	3d	13–	4–
500....	4292.25	4292.29	*V-Mn*	(4) 6	3d	8–	8-L2
500....	4293.19	4293.24	*Zr–*	(2) 5	3d	...	L4
1200....	4294.23	4294.27	*Ti, Fe*	(2) 7	15	2, 15	L10, 4
500....	4294.96	4294.94	*Zr-Sc*	2	2	4-5	4-5
500....	4295.25	4295.29	*Dy–*	(2) 6	2	8–	5–
500....	4296.07	4296.06	*Ti-V-La-Gd*	(3) 4	3d	10-5-8-5	4-8-8-4
600....	4296.83	4296.80	*Fe, Zr-Ce*	(3) 4	5	-2-8	L2, L5-8
400....	4297.23	4297.29	*Cr-Gd*	(4) 7	1	2-3	1-4
400....	4297.90	4297.91	*Cr-V-Pr*	0	1	3-3-8	3-4-5
400....	4298.33	4298.36	–	1	1	...	...
500....	4298.88	4298.90	*Ti–*	(2) 4	2	12–	4–
550....	4299.18	4299.15	*Ca*	3	3	30	20
550....	4299.43	4299.41	*Ti, Fe*	4	3	4, 15	3, 4
1200....	4300.31	4300.31	*Ti-Mn-Ce*	(3) 5	15	3-4–	L8-L2-4
500....	4301.24	4301.26	*Ti*	4	2	15	3
750....	4302.10	4302.08	*Ti-Zr*	2	5	2-2	L5-5
750....	4302.75	4302.69	*Ca*	4	2	100	50
750....	4303.41	4303.42	*Fe–*	(2) 3	3d	...	L4–
400....	4303.93	4303.91	*Nd-Er*	(2) 3	1	20-3	10-2
450....	4304.65	4304.67	*Nd-Fe*	(2) 3	1	4-1	5–
600....	4305.62	4305.61	*Sr*	3	3	20	L100
600....	4305.98	4306.01	*Ti-Sc-Pr*	(3) 7	4d	20-8-20	8-6-10
350....	4306.43	(4306.45)	*V-Gd*	...	0	4-4	3-2
500....	4306.89	4306.86	*Ce-Nd*	2	2	4-2	4-2
500....	4307.55	4307.59	–	(2) 4N	1	...	...
750....	4308.01G	4307.91	*Ca*	3	15	30	20
		4308.08	*Fe-Ti*	6		30-4	15-L8
500....	4309.05	4309.00	*Zr-Fe*	(3) 5	0	2-1	4-1
600....	4309.78	4309.79	*Y*	1	4	20	L20
450....	4310.55	4310.54	*Ti*	2	0	1	1
450....	4310.92	4310.86	*Ce*	2	0	1	1
500....	4311.72	4311.72	*Ti-Ce-*	(3) 6	1	1-1-	1-1-
450....	4312.24	4312.25	–	2	0	...	...
600....	4312.98	4313.03	*Ti*	3	10	2	L8
800....	4314.24	4314.25	*Sc*	3	10	30	30
800....	4315.13	4315.14	*Ti*	3	12	1	L8
400....	4316.12	4316.11	*Gd-La*	00	0	5-2	3-1

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
500....	4316.80	....	...	...	2	...	...
500....	4317.36	4317.35	*Zr*–	(2) 1	1	3–	6–
600....	4318.91	4318.82	*Ca, Ti-V*	4	4	50, 10-4	30, 3-1
800....	4320.93	4320.91	*Sc*	3	15	20	20
500....	4321.76	4321.81	*Ti*	0	1	8	3
500....	4322.58	4322.60	*La-V*	(3) 1	1	6-1	5-2
400....	4323.36	4323.32	–	(4) 4	2d	...	...
400....	4323.89	4323.92	–	(2) 4	0d	...	...
750....	4325.18	4325.15	*Sc*	4	6	20	20
900....	4325.95	4325.94	*Fe-Nd*	8	12	30-15	15-5
450....	4327.20	4327.27	*Fe, Gd*	3	1	1, 10	1, 4
500....	4327.97	4327.96	–	00	1	...	...
500....	4329.10	4329.10	–	(3) 1	1N	...	...
600....	4330.23	4330.19	*V*	0N	2	10	8
600....	4330.82	4330.87	*Ti*	2	3	...	L3
500....	4331.82	4331.81	*Ni*	2	1	3	2
500....	4332.96	4332.99	*V*	0	1	10	8
500....	4333.88	4333.92	*La*	1N	5	20	15
500....	4335.43	4335.43	–	1Nd?	0	...	...
500....	4336.12	4336.08	–	00	1	...	...
600....	4337.28	4337.22	*Fe*	5	2	6	2
900....	4338.04	4338.08	*Ti*	4	15	2	L10
450....	4338.83	4338.85	*Nd-Pr*	0	1	6-4	5-4
8000....	4341.17	4340.63	H_γ	20N	80	...	...
350....	4342.29	4342.35	*Gd*	0	1N	10	10
500....	4343.25	....	...	...	2N	...	...
400....	4343.79	4343.86	*Fe*	2	1	...	...
600....	4344.55	4344.60	*Ti, Cr*	(2) 6	5	1-10	L3-10
400....	4346.95	4346.99	*Cr*	1	0	3	2
400....	4347.55	4347.55	*Gd*–	(2) 2	0d	3	3
500....	4348.06	4348.05	*Zr-Sa-Fe*	(2) 3	2	3-10-1	3-6-
400....	4349.10	4349.11	*Fe-Zr*	2	1	1-2	–1
400....	4349.90	4349.97	*Ti-Ce*	00	1	–4	L2-6
400....	4351.30	4351.27	*Cr-Nd*	(2) 3	2	8-10	4-8
600....	4352.02	4352.01	*Cr, Mg*	(2) 10	12	15, 10	10, 2
500....	4352.97	4352.91 4353.04	*Fe* *V*	4 0	5d?	4 10	2 6
350....	4353.80	4353.77	*Ce-La*	(4) 1	0	...	...
400....	4354.34	4354.33	*Ti-Nd*	(2) 1	0N	2-1	2–
500....	4354.90	4354.90	*Sc-V*	(2) 2	3	3-2	5-3
350....	4355.24	4355.26	*Eu*	2	0	4	3
350....	4356.17	4356.16	*V-Nd*	1	2	3-3	3-3
350....	4356.88	4356.86	–	(4) 2	1	...	...
500....	4358.29	4358.27	*Nd*–	(4) 2	2N	10–	8–
500....	4358.90	4358.88	*Y-Zr*	0	4	8-3	L10-2
500....	4359.81	4359.82	*Cr, Zr*	(2) 4	5	10, 6	6, L15
350....	4360.53	4360.54	*Ti*–	(2) 2	0	2–	2–
400....	4361.03	4360.96	*Zr*	1	0	5	2
350....	4362.15	....	...	...	0N	...	...
400....	4362.72	4362.69	–	1	1	...	...
450....	4363.34	4363.27	*Cr*	1N	2	3	2

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
450....	4364.35	4364.35	*V-Nd*	1	2	2-3	3-3
450....	4364.82	4364.83	*Ce-La*	∞	2	8-3	5-3
350....	4365.49	4365.53	–	(2) 1	0	...	...
350....	4365.99	4366.06	*Fe*	2	0	1	...
400....	4366.72	4366.75	*Zr*–	(2) 2	2d	5–	3–
500....	4367.89	4367.84	*Ti*	2	4	1	L6
350....	4368.11	4368.11	*Fe, V*	(2) 3	0	1, 4	–, 3
400....	4368.65	4368.63	*V-Nd-Pr*	(2) 1	0	2-4-10	3-4-10
400....	4369.55	4369.57	*Er*	1	1	2	2
500....	4369.88	4369.93	*Fe-Ti-Gd*	(2) 5	4	3-3-5	2-2-4
500....	4371.17	4371.14	*Zr*	1	3	4	L15
400....	4371.44	4371.44	*Cr*	2	1	10	8
350....	4371.74	4371.77	–	(2) 1	0N	...	...
400....	4372.41	4372.50	*Ti*	0d?	0	2	2
400....	4373.73	4373.73	*Fe*	2	1N	1	...
550....	4374.65	4374.63	*Sc*	3	10	20	30
550....	4375.16	4375.10	*Y-Nd*	2	15	50-10	100-6
500....	4376.16	4376.11	*Fe-Ce*	6	6	5-8	2-3
450....	{4376.97	{4376.94	*Cr*	1	1N	2	2
400....	{4377.40	{4377.38	–	2N	1	...	...
350....	4377.97	4377.95	*Fe*	1	0	...	...
400....	4378.42	4378.42	*Cu-Sa-Er*	2Nd?	2	20-4-2	20-4-2
450....	4379.41	4379.40	*V*	4	3	30	30
400....	4379.92	4379.93	*Zr*	0	2	1	L4
400....	4380.87	4380.88	*Gd*	2Nd	1	2	3
350....	4381.35	4381.33	*Cr*	(2) 1	0	...	...
400....	4381.80	....	...	...	0	...	...
450....	4382.32	4382.32	*Ce-Er*	∞	2	10-3	5-2
400....	4383.15	4383.16	–	0	0	...	...
1600....	4383.70	4383.72	*Fe*	15	15	100	20
400....	{4384.43	{4384.48	*Ni-Pr*	(3) 2	1	3-3	2-3
450....	{4384.85	{4384.87	*V*	3	2	30	30
400....	{4385.30	{4385.24	*Cr-La*	(3) 4	0	8-2	5-3
600....	{4385.60	{4385.55	*Fe*	2	5	...	L3
450....	4386.97	4387.01	*Ti-Ce*	1	3	–10	L5-2
400....	4387.65	4387.66	*Cr*	0	0	3	2
2000....	4388.04	(4388.10)	*He*	...	2	...	...
400....	4388.55	4388.57	*Fe-Er*	3	2	2-1	1-3
400....	4389.40	4389.41	*Fe*	2	0	1	...
400....	4390.11	4390.15	*V*	2	2	20	20
350....	4390.63	4390.65	*Fe*–	(2) 2	1	...	...
500....	4391.12	4391.15	*Ti-Fe-Gd-Sa*	(2) 3	3d	-1-3-10	L2-1-3-10
500....	4391.83	4391.89	*Cr-Ce*	(2) 2	3	3-8	2-8
350....	4392.63	....	...	...	0	...	...
400....	4393.17	4393.20	*V*	0	0	2	2
500....	4394.17	4394.19	*Ti*	(2) 3	3	5	4
2500....	4395.29	4395.29	*Ti-V-Zr*	(2) 5	25	10-15-3	L20-10-2
500....	4396.05	4396.01	*Ti*	1	2	...	L2
350....	4396.73	4396.79	–	∞	0	...	...
400....	4397.34	4397.31	–	∞	0N	...	...

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
750....	4398.32	4398.18	*V*	1	8	10	15
		4398.46	–	0	...	...	...
800....	4399.95	4399.98	*Ti*	3	12	3	L7
800....	4400.68	4400.60	*Sc, V*	(2) 4	12	20, 10	20, 10
350....	4401.08	4401.02	*Nd-Ni*	0N	0	10-1	5-1
400....	4401.73	4401.71	*Ni*	2	6	15	8
350....	4402.95	....	...	...	0	...	...
400....	4403.52	4403.53	*Zr-Cr*	0	3d	–3	L1-3
400....	4404.43	4404.43	*Ti*	1N	2	10	4
800....	4404.95	4404.93	*Fe*	10	15	50	15
350....	4405.92	4405.90	*Pr*	0Nd?	0	8	5
350....	4406.27	4406.32	*V*	0	0	3	3
400....	4406.84	4406.81	*V-Gd*	2	2	10-5	5-10
350....	4407.20	4407.16	*Nd-Eu*	00	0	3-1	2-5
450....	4407.83	4407.81	*V*	2	2	1	4
450....	4408.48	4408.54	*V*	(2) 4	4d	23	16
400....	4408.82	4408.82	–	00	1	...	...
400....	4409.54	4409.56	*Ti-Er*	(3) 1	2	–5	2-2
300....	4410.29	4410.33	–	00N	0	...	...
500....	4410.69	4410.68	*Ni*	2	2	5	1
500....	4411.24	4411.24	*Ti-Cr-Nd*	1	4	-2-8	L5-2-5
400....	4412.00	4412.07	*Ti-Mn*	(2) 2	0	–3	1-2
500....	4412.31	4412.35	*V*–	(2) 1	2	4–	3–
350....	4413.73	4413.76	–	1	1	...	...
350....	4414.28	4414.28	*Zr, Gd*	00	0	2, 4	3, 1
350....	4414.79	4414.71	*Zr*	00	2	3	4
500....	4415.26	4415.29	*Fe*	8	10	20	20
500....	4415.69	4415.72	*Sc*	3	10	20	20
500....	4417.00	4416.98	*Ce*–	2	8	3–	3–
450....	4417.38	4417.45	*Ti*	0	1	5	2
500....	4417.87	4417.88	*Ti*	3	15	2	L6
500....	4418.36	....	...	...	2	...	...
350....	4419.03	4419.02	*Ce, Gd*	(2) 1	1	8, 5	5, 8
300....	4419.82	4419.77	*Er-Pr*	000	0	10-4	10-3
300....	4420.13	4420.10	*V*	00N	1	3	3
400....	4420.68	4420.69	*Zr-Sa*	00	2	4-10	2-6
350....	4421.41	4421.39	*Gd-Sa-Pr*	(2) 0	0	3-10-4	8-5-3
450....	4422.07	4422.04	*Ti*	(2) 1	2	2	L3
500....	4422.77	4422.74	*V*	3	3	10	L10
350....	4423.37	4423.34	*V-Fe*	(2) 2	1	3–	3–
350....	4423.98	4424.01	*Fe?*	2	1	...	...
400....	4424.51	4424.46	*Sa, Cr*	0	3	20, 3	10, 2
600....	4425.48	4425.61	*Ca*	4	5	100	20
400....	4426.05	....	...	...	1	...	...
400....	4426.29	4426.20	*Ti-V*	0Nd?	1	4-4	2-4
400....	4426.82	4426.84	*Er*	000Nd?	0N	3	1
600....	4427.43	4427.42	*Ti, Fe*	(2) 7	10	10, 8	4, 2
350....	4427.91	4427.91	*La-Ce*	(3) 0	1	3-4	8-3
350....	4428.55	4428.62	*V-Ce*	(2) 1	1	5-4	4-3
350....	4429.33	4429.37	*Ce-Pr*	00	2	8-30	5-15
450....	4430.15	4430.15	*La*	(2) 0N	4	20	10

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
450....	4430.70	4430.79	*Fe-Gd*	3	2	5-5	1-2
350....	4431.45	4431.44	*Ti-Sc*	(3) 1	1	2-2	1-3
350....	4431.81	4431.78	–	00	0	...	...
350....	4432.37	4432.33	*Cr*	0	0	2	2
300....	4432.86	4432.90	–	00	0	...	...
350....	4433.36	4433.39	*Fe*	3	2	4	1
350....	4434.04	4434.02	*Ti-Fe-Sa*	(3) 2	2d	4-1-10	3-6
300....	4434.48	4434.50	*Sa*	00	1	20	8
600....	4435.14	4435.13	*Ca*	5	7	100	20
600....	4435.68	(4435.74)	*Eu*	...	6	50	30
		4435.85	*Ca*	4		50	15
350....	4436.35	4436.31	*V-Gd*	0	2	5-4	5-16
350....	4437.09	4437.11	*Ni*	2d?	2	3	1
750....	4437.86	(4437.72)	*He*	...	...	...	...
		4437.86	*V*	(2) 1	1d	10	6
350....	4438.39	4438.39	*Sr, Zr, Ti*	(3) 2	1	20, 3, 2	4, 2, 1
300....	4438.73	4438.74	–	(2) 0	0	...	...
300....	4439.47	4439.52	–	00	0	...	...
300....	4440.00	4440.05	*Fe*	1	0	...	...
350....	4440.53	4440.59	*Zr-Ti*	1	3	3-4	L5-2
300....	4441.08	4441.04	*Ce-Fe*	(2) 2	1d	3–	2–
350....	4441.90	4441.88	*V*	3Nd?	3	10	8
350....	4442.49	4442.51	*Fe*	6	3	8	2
400....	4443.19	4443.16	*Zr*	0	3	5	L15
1600....	4444.01	4443.98	*Ti*	5	20	4	L15
450....	4444.76	4444.73	*Ce-Ti*	2	4	13–	7-1
300....	4445.39	....	...	...	0	...	...
300....	4445.83	4445.84	–	00	0	...	...
350....	4446.39	4446.41	*Nd*	00	3	10	10
350....	4447.17	4447.16	*Fe, Mn*	(2) 4	2d	2-1	–4
450....	4447.89	4447.89	*Fe*	6	4	8	2
400....	4449.34	4449.31	*Ti*	2	4	10	5
350....	4449.85	4449.88	*V-Pr-Dy*	00	2	2-10-10	3-4-4
600....	4450.53	4450.59	*Ti-Zr*	(2) 3	8	1-3	L4-2
350....	4450.93	4450.92	*Ce*	00	2	8	4
500....	4451.71	4451.75	*Fe-Mn-Nd*	3	3	2-5-10	L3-10-10
300....	4452.17	4452.17	*V*	0N	1	10	10
400....	4452.92	4452.90	*Sa*–	(3) 1	1d	10–	5–
350....	4453.46	4453.49	*Ti*	2	1	8	3
350....	4453.88	4453.88	*Ti*	1	1	8	3
500....	4454.57	4454.55	*Zr-Fe*	3	2	–2	L2-1
500....	4454.93	4454.95	*Ca-Zr*	5	6	200-4	30-5
400....	4455.45	4455.48	*Ti-Mn*	2	2	12-3	4-3
500....	4456.02	4456.03	*Mn, Ca*	(2) 5	3d	3, 20	3, 15
350....	4456.68	4456.70	*V, Nd, Ca*	(2) 3	1N	2, 3, 8	3, 4, 5
300....	4457.20	4457.21	*Mn*	0	0	4	2
500....	4457.68	4457.66	*Ti-Zr-V-Mn*	(2) 4	3d	15-3-4-4	5-5-3-4
300	4458.24	4458.24	–	2	0	...	...
350....	4458.76	4458.69	*Cr-Sa*	0	0	3-8	3-6

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
450....	4459.27	4459.26	*Ni, Fe*	(2) 5	3	10, 10	8, 3
300....	4459.52	4459.52	*Cr*	1	0	1	...
350....	4459.97	4459.92	*V*	1	1	8	6
350....	4460.53	4460.49	*V, Ce*	(2) 1	4	10, 10	10, 10
350....	4461.28	4461.30	*Mn, Zr, Ce*	(2) 2	2	5-5	4-L1-14
500....	4461.75	4461.82	*Fe*	4	4	10	2
350....	4462.14	4462.16	*Fe, Mn*	3Nd?	2	-10	L2-8
350....	4462.68	4462.62	*V-Ni*	1	1	8-8	10-3
350....	4463.18	4463.15	*Nd*	00	2	10	15
350....	4463.67	4463.63	*Ti-Ni-Ce*	(2) 1	2	8-1-5	2-4
500....	4464.72	4464.73	*Ti-Mn*	(2) 4	6d	1-8	L3-5
300....	4465.46	4465.52	*Cr*	0	0	2	2
350....	4465.88	4465.91	*Ti-Nd*	(2) 1	1	5-3	3-3
500....	4466.75	4466.73	*Fe*	5	4	10	3
300....	4467.09	4467.10	*Co-Zr*	1	0	5-3	3-2
350....	4467.46	4467.50	*Sa*	00	1	10	10
300....	4467.94	4467.96	*V-Nd-Ce*	(3) 1	0	3-3-4	3-3-3
1500....	4468.71	4468.66	*Ti*	5	20	4	L15
400....	4469.53	4469.54	*Fe*	4	2	6	3
350....	4469.76	4469.78	*Co, V*	(2) 1	0	5-5	8-8
350....	4470.27	4470.30	*Mn*	1	0	3	4
400....	4470.63	4470.65	*Ni-Zr*	2	2	10-4	3-3
7500....	4471.71	4471.65	*He*	...	40	...	...
300....	4472.55	4472.58	*Sa*	00	0	4	3
400....	4473.04	4472.97	*Mn-Ce-Fe*	(3) 2	4	8-4-	3-3-
300....	4474.21	4474.21	*V*	00	0	4	5
300....	4474.90	4474.91	*V*	00	1	5	5
300....	4475.71	4475.74	*Ti-Nd*	00	0	1-1	1-
500....	4476.20	4476.18	*Fe*	4	5	10	4
300....	4476.97	....	...	...	0	...	...
300....	4477.42	4477.43	*Y-Pr*	(2) 0	0d	4-6	2-3
300....	4478.13	4478.19	–	0	1	...	...
300....	4478.89	4478.89	*Mn-Gd-Sa*	(2) 0	0	-4-5	L2-5-5
350....	4479.72	4479.74	*Ce-Ti-Mn*	(3) 2	2d	10-4-1	4-2-1
350....	4480.24	4480.25	*V*	(2) 1	1	3	3
300....	4480.70	4480.75	*Ti-Ni*	0N	0	3-1	1-
400....	4481.39	4481.40	*Mg, Ti*	(2) 1	3d?	-, 8	L50, 3
500....	4482.39	4482.38	*Fe*	(2) 8	5	10	4
300....	4482.87	4482.90	*Ti*	1	2	3	2
300....	4483.45	....	...	...	0	...	...
350....	4484.29	4484.34	*Fe-Ce*	(2) 4	2N	4-4	4-2
350....	4485.82	4485.85	*Fe*	3	3	2	1
350....	4487.09	4487.08	*Ce*	0	3	10	4
300....	4487.53	4487.53	*Y*	00	0	7	6
350....	4488.40	4488.40	*Ti*	(2) 2	3	1	L6
300....	4488.76	....	...	...	0	...	...
400....	4489.37	4489.35	*Fe*	2	6	...	L1
400....	4489.89	4489.91	*Fe*	4	1	3	1
400....	4490.26	4490.25	*Mn-Fe*	3N	2	5-1	3-1
350....	4490.82	4490.88	*Fe-Ni*	(2) 2	1	1-1	1-
450....	4491.63	4491.57	*Fe*	2	6	...	L2

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
350....	4492.66	4492.66	*Cr-Fe*	(2) 1	1d	2−	2−
350....	4493.67	4493.70	*Ba*	1	2	6	1
300....	4494.14	4494.18	−	(2) 1	0	...	...
400....	4494.71	4494.74	*Fe-Zr*	6	3	10−	5-L15
350....	4495.53	4495.54	*Ce-Ti*	(4) 3	1	3−	2−
350....	4496.32	4496.32	*Ti-V*	1	2	10-3	3-6
400....	4497.11	4497.14	*Zr*	0	3	3	15
300....	4498.11	4498.03	*Ce, Nd*	000	0	3, 3	3, 3
350....	4499.02	4499.07	*Mn*	1	0	8	4
350....	4499.62	4499.67	*Sa*	000	0	4	3
350....	4500.43	4500.45	*Cr*	0	1	3	2
1600....	4501.45	4501.45	*Ti*	5	20	4	L15
300....	4501.97	4501.95	*Nd*	0Nd?	0	8	5
300....	4502.45	4502.39	*Mn*	2	0	8	4
300....	4505.00	4505.00	*Fe*	1	0	1	1
350....	4505.56	4505.52	−	(3) 1	0d	...	...
300....	4506.51	4506.50	*Gd-Ti*	00	0	7-1	4-1
350....	4506.92	4506.90	*Mn−*	(3) 1	1d	1−	...
300....	4507.47	4507.40	*Zr*	0	0	10	3
600....	4508.49	4508.46	*Fe*	4	8	...	L5
300....	4509.46	4509.46	*Ni-V*	0N	1	−1	L2-2
300....	4510.04	4509.99	−	(2) 1	0	...	...
300....	4511.26	4511.23	*Ti*	00	0	2	1
350....	4511.91	....	...	...	1	...	...
450....	4512.90	4512.91	*Ti*	3	2	15	4
300....	4514.09	....	...	...	0	...	..
350....	4514.56	4514.51	*Cr-V-Gd*	(3) 3	2d	8-2-3	3-3-5
600....	4515.48	4515.51	*Fe*	3	6	...	L4
300....	4516.45	4516.44	*Nd*	0N	0	3	3
350....	4517.72	4517.70	*Fe*	3	1	2	1
400....	4518.20	4518.20	*Ti*	3	2	15	4
400....	4518.47	4518.51	−	1	3	...	...
350....	4519.64	....	...	...	1	...	...
600....	4520.38	4520.40	*Fe*	3	8	1	L3
400....	4521.35	4521.30	*Cr*	0	1	2	2
350....	4522.50	4522.54	*La*	00	1	8	15
600....	4522.83	4522.83	*Fe-Ti-Eu*	(3) 6	12	2-15-20	L6-4-L20
350....	4523.23	4523.25	*Ce-Sa*	0	1	5-8	4-4
350....	4524.05	4524.09	*Sa*	00	1	8	5
350....	4524.81	4524.86	−	0	1	...	...
350....	4525.31	4525.31	*Fe-Ba*	5	3	4-10	3-50
350....	4526.26	4526.27	*La*	0	1	5	8
350....	4527.10	4527.10	*Ca-Er*	3	1	20-3	2-3
400....	4527.49	4527.49	*Ti-Ce*	3	3	15-10	4-5
400....	4528.76	4528.80	*Fe-V*	8	5	10-1	6-L6
400....	4529.71	4529.74	*Ti-V-Al*	(3) 3	4d	−3−	L3-2-L8
400....	4531.08	4531.12	*Co*	2	1	15	10
400....	4531.33	4531.33	*Fe*	5	3	5	2
350....	4531.80	4531.80	*Fe*	2	1	...	...
400....	4533.34	4533.32	*Ti−*	(2) 5	2d	20−	5−
1200....	4534.20	4534.17	*Ti-Co*	(3) 7	15	2-3	L5-4

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
400....	4534.89	4534.95	*Ti*	4	2	15	4
400....	4535.74	4535.74	*Ti*	3	3	8	3
400....	4536.15	4536.16	*Ti*	(2) 4	3	20	4
300....	4536.72	4536.68	*Sa*	00	0	4	2
300....	4537.34	4537.39	*Ti*	00	0	1	1
350....	4538.00	4537.94	*V-Gd-Sa*	(2) 1	1N	2-4-8	3-3-4
350....	4539.17	4539.17	*Ti-Fe-Ce*	(5) 2	0N	2-1	1-1
400....	4539.96	4539.95	*Ce-Cr*	0N	3	10-3	4-3
400....	4540.77	4540.78	*Cr*	(2) 4	2	6	7
400....	4541.66	4541.64	*Fe-Cr-Nd*	(2) 3	4d	1-1-5	L3-1-5
300....	4542.23	4542.23	*Sa-Gd*	000	0	8-2	3-1
350....	4542.42	4542.40	*Zr*	0N	1	6	3
350....	4542.87	4542.83	*Nd–*	(2) 1	1	4–	5–
350....	4543.40	4543.40	–	0	0	...	...
400....	4544.11	4544.12	*Co-Ti-Sa*	(2) 2	2d	3–10	4-1-5
400....	4544.84	4544.84	*Ti-Cr*	(2) 4	2	15-4	3-4
400....	4545.28	4545.31	*Ti*	1	2	...	1
400....	4546.12	4546.13	*Cr*	3	2	5	4
350....	4546.85	4546.85	–	00	0	...	...
400....	4547.20	4547.15	*Ni-Fe*	(3) 4	2	6-1	3-1
400....	4548.02	4548.02	*Fe*	3	2	3	2
400....	4549.00	4548.94	*Ti*	2	0	8	3
1300....	4549.80	4549.77	*Ti-Fe-Co*	(2) 8	20	3-1-4	L20-L7-5
350....	4550.80	....	...	...	1	...	...
350....	4551.33	4551.40	*Ni*	0	1	1	1
400....	4552.63	4552.63	*Ti*	2	3N	15	4
300....	4553.16	4553.21	*Zr, V*	00	0	4-3	1-5
1200....	4554.28	4554.21	*Ba-Zr*	8	20	1000–	L1000-8
350....	4555.02	4554.98	*Cr-Sa*	(2) 3	1	1-5	L6-3
350....	4555.69	4555.66	*Ti-Zr*	3	2	15-3	3-2
500....	4556.06	4556.06	*Fe-Cu*	3	10	...	L5-L5
300....	4557.46	4557.46	–	0N	0	...	...
500....	4558.74	4558.79	*Cr-La*	(2) 3	8d	1-5	L20-5
300....	4559.54	4559.52	*La, Y*	000	0	3, 4	3, 2
350....	4560.26	4560.27	*Fe*	2	1	1	1
450....	4560.50	4560.52	*Ce-Sa*	(2) 0	2	5-5	5-3
350....	4560.87	4560.89	*V*	00	0	8	9
400....	4561.18	4561.14	*Ce*	00	1	4	3
300....	4561.59	4561.59	–	1	0	...	...
450....	4562.47	4562.54	*Ce*	1	4	10	10
350....	4563.18	....	...	...	1	...	...
1200....	4563.93	4563.94	*Ti*	4	15	3	L10
350....	4564.79	4564.75	*V*	00	1	1	L10
400....	4565.67	4565.69	*Cr-Zr*	3	2	4-2	2-2
400....	4565.88	4565.84	*Co*	2	1	8	8
350....	4566.38	4566.41	*Sa*	00N	0	10	5
300....	4566.96	....	...	...	0	...	...
300....	4567.84	....	...	...	0	...	...
300....	4568.36	....	...	...	1	...	...
350....	4568.88	4568.85	*Fe–*	(2) 2	1	1	1
300....	4569.56	4569.61	*Co-Cr*	(2) 0	1	–4	L2-3

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
300....	4570.08	....	...	...	0	...	...
300....	4570.84	....	...	...	0	...	...
400....	4571.25	4571.28	*Mg*	5	3	5	...
1200....	4572.17	4572.16	*Ti*	6	20	5	L20
300....	4574.05	(4574.02)	*Ba*	...	0	10	5
350....	4574.91	4574.90	*Fe*	2	1	1	1
500....	4576.49	4576.51	*Fe*	2	4	...	L1
350....	4577.37	4577.36	*V*	0	1	8	8
350....	4577.82	4577.87	*Sa*	00	1	10	5
350....	4578.71	4578.73	*Ca*	3	0	20	4
350....	4578.97	4578.91	*V*	00N	1	4	4
300....	4579.41	4579.45	*V, Nd*	(2) 0	1	2, 5	2, 4
400....	4580.12	4580.22	*Cr-La*	3	3	8-3	4-3
400....	4580.59	4580.59	*V*	1	2	8	10
350....	4581.59	4581.58	*Ca*	4	3	30	4
300....	4582.38	....	...	...	0	...	...
450....	4582.84	4582.83	–	(2) 1	2d	...	...
1100....	4584.04	4584.02	*Fe-V*	4	15	1-2	3-L8
350....	4584.93	4584.97	*Fe-Sa*	(2) 3	1d	1-5	1-4
300....	4585.45	4585.52	–	0	0	...	...
400....	4586.08	4586.05	*Ca*	4	2	30	8
400....	4586.48	4586.48	*V-Cr*	(2) 2	2	10-1	8-1
350....	4587.28	4587.31	*Fe*	2	1	1	1
600....	4588.37	4588.38	*Cr*	3	5	1	L20
500....	4590.10	4590.13	*Ti*	3	6	1	L3
300....	4590.72	(4590.72)	*Zr*	...	0	3	2
350....	4591.39	4591.42	*V*	00	1	4	8
350....	4591.56	4591.57	*Cr*	2	2	8	2
350....	4592.09	4592.16	*Cr-Sa*	(2) 1	2	–3	L4-3
350....	4592.70	4592.71	*Ni*	2	3	10	4
300....	4593.70	4593.70	*Sa*	1	1	4	4
400....	4594.16	4594.20	*V-Eu-Ce*	(3) 3	3d	10-50-10	10-20-10
300....	4594.80	4594.82	*Co-Nd*	00N	0	10-3	3-2
350....	4595.45	4595.53	*Fe-Sa*	2	2	1-5	1-5
350....	4596.04	4596.10	*Cr-Fe*	(2) 3	1N	3–	2–
350....	4597.15	4597.12	*Co-Nd-Gd*	(2) 1	1d	10-3-4	3-3-4
350....	4597.90	4597.93	–	1	2	...	...
300....	4598.31	4598.30	*Fe*	3	1	2	1
300....	4598.92	4598.92	–	0	0	...	...
300....	4599.84	....	...	...	0	...	...
350....	4600.34	4600.31	*V-Cr*	(2) 1	1	1-3	L8-2
400....	4600.91	4600.93	*Cr*	3	2	5	3
350....	4601.33	4601.28	*Cr-Gd*	(2) 1	1	3-5	2-5
350....	4602.20	4602.18	*Fe*	3	2	2	...
400....	4603.12	4603.13	*Fe*	6	3	5	2
300....	4603.78	4603.80	–	00	0	...	...
300....	4604.70	4604.74	–	2	0	...	...
350....	4605.13	4605.17	*Ni*	3	2	10	3
300....	4605.84	4605.77	–	2	1	...	...
350....	4606.46	4606.45	*Ni-Ce*	(2) 2	2d	3-4	2-5
350....	4607.48	4607.51	*Sr*	1	2	1000	50

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
350....	4607.84	4607.83	*Fe*	4	1	2	1
300....	4608.36	....	...	...	0	...	...
300....	4609.43	4609.45	–	0	1	...	...
300....	4610.09	4610.09	–	0	1	...	...
400....	4611.46	4611.47	*Fe-Er*	5	3	4-4	2-2
300....	4611.99	....	...	...	0	...	...
300....	4612.64	....	...	...	0	...	...
400....	4613.50	4613.46	*Cr-La-Fe*	$(^2)$ 6	4	8-5-2	3-5-1
350....	4614.10	4614.10	*Zr*	1	2	1	3
300....	4614.58	4614.62	*Ti-Gd*	00	1	1-3	1-2
300....	4615.74	4615.74	*Sa*	1	2	14	14
400....	4616.26	4616.30	*Cr*	4	3	10	4
350....	4616.80	4616.80	*Cr*	1N	1	...	L3
350....	4617.47	4617.45	*Ti*	3	2	10	8
300....	4618.13	4618.15	–	00	0	...	...
600....	4618.98	4618.97	*Cr-Fe*	4d?	4	–1	L8-1
350....	4619.47	4619.47	*Fe*	3	2	3	1
300....	4619.98	4619.96	*V-La*	00	0	8-4	10-6
400....	4620.72	4620.69	*Fe?*	1	4	...	...
300....	4621.36	....	...	...	1	...	...
350....	4622.08	4622.10	*Cr*	$(^2)$ 1	2d	3	2
350....	4622.57	4622.63	*Cr*	1	1	2	2
350....	4623.27	4623.28	*Ti*	2	3	10	4
300....	4624.57	4624.59	*V*	00N	0	3	3
350....	4625.20	4625.23	*Fe*	5	2	3	1
400....	4626.39	4626.36	*Cr*	5	3	10	5
300....	4626.78	4626.72	*V, Mn*	0	0	3, 4	2, 2
300....	4627.61	4627.64	*Eu*	$(^2)$ 1	1d	50	15
400....	4628.42	4628.34	*Ce*	0	3	10	10
800....	4629.63	4629.52	*Ti-Fe-Co*	6	12	8–10	3-L4-5
300....	4630.32	4630.31	*Fe*	4	1	2	...
300....	4632.36	4632.32	*Cr*	0	0	2	1
400....	4632.99	4633.06	*Fe–*	$(^2)$ 5	2	3	1
300....	4633.43	4633.43	*Cr*	0	0	2	1
300....	4633.94	4633.95	–	0N	0	...	...
500....	4634.21	4634.25	*Cr-Zr*	2	3	–10	L10-3
300....	4636.00	4636.03	*Fe*	2	0	1	...
300....	4636.48	4636.50	–	0	0	...	...
300....	4637.31	4637.35	*Cr*	0	0	2	1
350....	4637.66	4637.68	*Fe*	5	1	3	1
350....	4638.19	4638.19	*Fe*	4	2	3	1
350....	4639.69	4639.69	*Ti*	$(^2)$ 4	2	8	4
350....	4640.34	4640.29	*Ti-V*	$(^2)$ 2	2d	4-3	2-3
300....	4641.31	4641.31	–	$(^2)$ 1	0N	...	...
350....	4642.48	4642.42	*Sa*	00	2	10	4
400....	4643.58	4643.64	*Fe*	4	2	2	...
350....	4644.36	4644.39	–	$(^3)$ 1	1N	...	...
350....	4645.48	4645.52	*Ti–*	$(^2)$ 1	1	5–	3–
600....	4646.33	4646.35	*Cr*	5	5	20	10
300....	4646.89	4646.86	*Cr-Sa*	$(^2)$ 1	1	2-5	1-3
500....	4647.63	4647.62	*Fe*	4	2	3	2

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
300. . . .	4648.22	4648.19	*Cr–*	(2) 1	0	2–	1–
500. . . .	4649.03	4648.96	*Ni-Cr*	(4) 5	2d	15-2	3-2
300. . . .	4649.62	4649.61	*Cr*	0	0	3	2
300. . . .	4650.20	4650.19	*Ti*	0	0	3	2
400. . . .	4651.46	4651.46	*Cr*	4	2	8	3
400. . . .	4652.33	4652.34	*Cr*	5	3	10	5
350. . . .	4653.59	4653.61	–	(2) 0	0	. . .	. . .
350. . . .	4654.28	4654.33	*Cr*	0	0	1	. . .
350. . . .	4654.81	4654.80	*Fe*	5	3d	5	2
300. . . .	4655.90	4655.90	*Ti, Ni*	(2) 1	1N	1, 2	1, 1
350. . . .	4656.61	4656.64	*Ti*	3	1	8	3
400. . . .	4657.27	4657.30	*Ti-V*	(2) 3	3d	–1	L2-1
300. . . .	4660.36	4660.40	–	(4) 1	0d?	. . .	. . .
300. . . .	4662.14	4662.15	*Fe, Eu*	1	0	1, 50	1, 15
300. . . .	4662.94	4662.99	–	(3) 1	0N	. . .	. . .
350. . . .	4663.52	4663.52	*Cr, Co*	(2) 2	1	3, 10	2, 5
350. . . .	4663.99	4663.96	*La, Cr*	1	2	4, 3	8, 2
250. . . .	4664.51	4664.50	–	00N	0	. . .	. . .
300. . . .	4665.00	4664.96	*Cr*	3	0	5	2
300. . . .	4666.26	4666.23	*Cr-V*	(2) 2	1d	3-2	3-3
400. . . .	4666.91	4666.89	*Cr–*	(4) 4	3N	1–	2–
400. . . .	4667.79	4667.77	*Ti*	3	3	10	5
350. . . .	4668.30	4668.30	*Fe–*	(2) 6	1d	4	2
350. . . .	4669.62	. . . .	. . .	. . .	2d	. . .	. . .
500. . . .	4670.55	4670.59	*Sc*	2	4	8	10
300. . . .	4671.57	4671.60	–	1	0	. . .	. . .
350. . . .	4672.51	4672.51	–	3N	1	. . .	. . .
350. . . .	4673.32	4673.35	*Fe*	4	2	2	1
350. . . .	4674.30	4674.28	–	1N	0	. . .	. . .
350. . . .	4674.82	4674.83	*Sa*	0N	1	10	5
300. . . .	4675.89	. . . .	. . .	. . .	0	. . .	. . .
350. . . .	4677.03	4677.10	*Ti, Sa*	00	0	1, 8	1, 4
250. . . .	4677.59	4677.60	*Ti*	00	0	1	1
350. . . .	4679.19	4679.12	*Fe-Ni-Er*	(2) 8	2N	4–8	2-L3-5
350. . . .	4680.31	4680.32	*Zn*	1	1	100	300
350. . . .	4680.89	4680.90	*Nd–*	(3) 1	1	3–	3–
300. . . .	4681.63	4681.65	–	1	0	. . .	. . .
400. . . .	4682.12	4682.09	*Ti*	3	2	10	6
350. . . .	4682.58	4682.53	*V-Co*	1	2	4-10	10-4
300. . . .	4683.70	4683.74	*Fe*	3	1	1	1
300. . . .	4684.42	4684.46	–	(2) 0N	1	. . .	. . .
350. . . .	4685.39	4685.39	*Zr-Ca*	2	1d	1-5	5-1
2000. . . .	4686.00	(4685.98)*	*H*	. . .	1N	. . .	. . .
300. . . .	4686.35	4686.40	*Ni*	3	1	6	3
300. . . .	4687.50	4687.51	*Fe–*	(3) 3	0d	. . .	. . .
300. . . .	4687.94	4687.98	*Zr*	0	0	15	8
300. . . .	4688.72	4688.70	*Zr-Sa*	(2) 1	1N	10-3	4-1
350. . . .	4689.50	4689.54	*Cr*	2	1	3	3
300. . . .	4690.31	4690.32	*Fe*	4	0	1	1
300. . . .	4690.95	4690.98	*Ti*	00	0	2	1

* Fowler's value, *M.N.*, 73, 62, 1913.

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
400....	4691.69	4691.62	*Fe-Ti*	(3) 7	3	4-5	2-3
300....	4692.75	4692.70	*C?*	00N	0	...	...
300....	4693.22	....	*C?*	...	0	...	...
300....	4693.97	4694.03	*Ti, Cr*	(2) 2	0	2, 2	2, 2
300....	4694.98	4695.04	*Cr*	1	0	1	...
300....	4695.45	4695.48	*Cr-C*	(2) 1	0	2–	1–
300....	4696.09	4696.03	–	00	0	...	...
300....	4696.74	4696.74	*C?*	(2) 0	0	...	...
300....	4697.40	4697.35	*Cr-C**	(2) 2	1	2–	2–
300....	4698.33	....	...	...	0	...	...
350....	4698.83	4698.80	*Ti-Cr*	(3) 3	3d	10-4	3-4
350....	4699.52	4699.51	*V-Sa*	4	1	2-3	1-2
350....	4700.33	4700.34	–	4	0	...	...
300....	4701.26	4701.23	*Fe*	1	0	1	1
300....	4701.69	4701.71	*Ni*	1	1	8	1
300....	4702.11	4702.08	*C*	0N	0	...	...
500....	4703.16	4703.18	*Mg*	10	3	20	5
350....	4703.93	4703.99	*Ni*	3	1	5	1
300....	4704.53	4704.58	*Sa–*	(3) 1	0N	8–	3–
300....	4705.10	4705.13	*Fe*	4	1	1	...
350....	4706.69	4706.73	*V, Nd*	0	1	2, 8	3, 4
350....	4707.48	4707.52	*Fe–*	(2) 7	2	6	2
300....	4708.18	4708.20	*Cr*	2	1	10	3
350....	4708.80	4708.85	*Ti*	2	2	...	2
300....	4709.10	4709.15	*Ti*	1	1	1	...
350....	4709.89	4709.90	*Mn, Nd*	2	2	8, 5	2, 4
350....	4710.41	4710.45	*Fe-Ti*	(2) 3	3	3-8	1-3
300....	4711.67	4711.66	*C*	0	1	...	...
250....	4712.27	4712.26	*Ni*	0	0	2	1
6000....	4713.32	4713.31	*He*	...	4	...	...
300....	4714.16	4714.21	*V, Ce*	(3) 1	0	3, 3	3, 3
400....	4714.58	4714.60	*Ni*	6	3	15	8
300....	4715.14	4715.09	*C*†	000	1	...	...
350....	4715.98	4715.95	*Ni*	4	2	10	3
300....	4717.00	4717.02	–	00	0	...	...
300....	4717.69	4717.67	*Zr–*	(2) 1	0	3	1
300....	4717.94	4717.89	*V-Sa*	000	0	3-4	3-3
350....	4718.61	4718.60	*Cr*	3	2	10	5
300....	4719.32	(4719.30)	*Zr*	...	0	5	3
300....	4719.70	4719.69	–	0	1	...	...
300....	4721.20	4721.18	*Fe*	2	1d	1	1
400....	4722.34	4722.34	*Zn*	3	3	200	500
300....	4723.48	4723.41	*Ti–*	(2) 0	0d	3–	2–
300....	4724.48	(4724.52)	*Nd*	...	1N	5	5
250....	4726.31	4726.33	*Fe?*	0	0	...	...
350....	4727.62	4727.62	*Fe, Mn*	(2) 5	2d	2, 8	1, 2
250....	4728.33	4728.35	–	0	0	...	...
350....	4728.75	4728.73	*Fe-Y*	4	2	2-5	1-3
300....	4729.64	....	...	...	0	...	...

* Third edge of fourth carbon band.

† Second edge of fourth carbon edge.

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
300....	4730.22	4730.21	–	2	1	...	...
300....	4731.06	4731.00	*Cr–*	(2) 2	1	4	3
400....	4731.64	4731.65	*Fe–*	4	3	1–	1–
300....	4731.92	4731.98	*Ni-Nd*	1	0	3-3	1-2
300....	4732.64	4732.64	*Ni-Y*	1	1	3-4	1-3
400....	4733.79	4733.78	*Fe*	4	2	3	1
350....	4734.26	4734.28	*Sc*	1	1	5	3
250....	4736.04	4736.03	*Fe*	3	1	1	1
400....	4736.97	4736.96	*Fe*	6	3	6	3
350....	4737.51	4737.54	*Cr*	2	2N	6	3
250....	4737.82	4737.82	*Sc*	1	1	5	3
350....	4739.30	4739.29	*Mn*	3	2	5	2
300....	4739.80	....	...	...	0	...	...
350....	4740.46	(4740.46)	*La*	...	2d	8	5
350....	4741.48	(4741.41)	*Sc-Y*	...	0N	5-4	3-3
300....	4741.74	4741.72	*Fe*	3	1	2	1
300....	4742.10	(4742.10)	*Sr*	...	0	10	3
300....	4743.23	(4743.26)	*La*	...	1	8	10
300....	4744.56	4744.57	–	3	1	...	...
300....	4745.52	4745.50	*Cr*	00	0	2	1
350....	4745.93	4745.99	*Fe*	4	2	2	1
250....	4748.36	4748.32	–	4	1	...	...
300....	4749.95	4749.99	*Co-Fe*	(2) 2	2d	10	4
250....	4751.29	4751.28	*V*	0	1	3	3
250....	4752.20	4752.29	*Cr-Ni*	2	1	3-2	3-1
300....	4752.60	4752.61	*Ni*	3	2	3	1
400....	4754.17	4754.22	*Mn*	7	3	30	8
300....	4754.92	4754.95	*Ni*	1	1	3	1
300....	4755.82	4755.89	–	00	0	...	...
300....	4756.25	4756.30	*Cr*	2	1	8	8
300....	4756.67	4756.70	*Ni*	3	2	8	3
300....	4757.73	4757.77	*V-Fe*	2	1	5-1	4-1
300....	4758.29	4758.31	*Ti*	1	2	10	5
350....	4759.50	4759.46	*Ti*	2	2	8	5
250....	4760.26	4760.26	–	00	0	...	...
250....	4761.28	4761.29	*V*	00N	1	5	3
350....	4761.74	4761.72	*Mn*	3	2	6	2
400....	4762.67	4762.61	*Mn-Er*	(2) 6	3d	10-5	4-3
300....	4763.02	4762.97	*Zr-Ti*	0	0	5–	2-1
350....	4764.17	4764.11	*Ti-Ni*	4d	4	–3	L1-2
300....	4764.72	4764.72	*Ti*	0	1	...	1
300....	4765.64	4765.65	–	2	1N	...	...
300....	4766.07	4766.05	*Mn*	3	1	6	3
350....	4766.55	4766.62	*Mn*	4	2	8	3
250....	4768.05	4768.05	*Cr*	00	0	...	...
300....	4768.45	4768.52	–	3	2	...	...
250....	4769.97	4769.99	*Ti*	00N	0	1	1
300....	4771.32	4771.28	*Ti, Co*	00	0	1, 5	1, 3
350....	4771.79	4771.76	*Fe–*	(2) 5	1d	1–	...
350....	4772.97	4773.01	*Fe*	4	1	2	1
250....	4773.55	4773.60	–	00	0	...	...

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
250....	{4776.30	{4776.26	*Fe*	00	0	...	...
300....	4776.59	4776.55	*V-Co*	0d?	1	10-4	10-3
300....	4777.83	....	...	...	0N	...	...
250....	4779.59	4779.63	*Fe*	1	0	1	...
500....	4780.15	4780.17	*Ti-Co*	2	4	-4	L4-5
250....	4781.66	4781.64	*Co*	000	0	3	2
500....	4783.65	4783.61	*Mn*	6	4	30	8
250....	4786.18	4786.14	*Nd-Sa*	0	0	3-3	2-1
450....	4786.78	4786.73	*Ni-V-Y*	3	3N	15-5-3	3-10-L5
300....	4787.84	....	...	...	0N	...	...
300....	4788.92	4788.95	*Fe*	3	0	2	1
400....	4789.65	4789.72	*Cr, Fe*	(2) 5	3d	5, 3	3, 2
300....	4791.33	4791.33	–	0	1d	...	...
350....	{4792.57	{4792.65	*Ti-Cr-*	(2) 2	2	4-4-	3-3-
350....	4793.10	4793.04	*Co*	1	2	10	8
250....	4794.01	....	...	...	0	...	...
250....	4794.56	4794.55	–	00	0	...	...
250....	4798.47	4798.45	*Fe*	1	0	1	1
400....	4798.80	4798.79	–	(2) 1	2d	...	...
300....	4799.64	4799.60	*Nd*	1	1	3	2
300....	4799.98	4799.98	*Ti*	1	1	3	3
300....	4800.82	4800.84	*Fe*	2	1	1	1
300....	4801.22	4801.21	*Cr-Gd*	1	1	5-3	3-3
300....	4802.82	....	...	...	1	...	...
300....	4804.02	....	...	...	0	...	...
800....	4805.31	4805.28	*Ti*	3	5	...	L4
300....	4806.63	....	...	...	0	...	...
300....	4807.08	....	...	...	0	...	...
300....	4807.40	....	...	...	0	...	...
300....	{4808.68	{4808.73	*Ti*	00	1	2	2
300....	4809.24	4809.20	*La-*	(2) 0	0	4-	3-
400....	4810.62	4810.72	*Zn*	3	2d?	200	500
300....	4811.48	(4811.49)	*Nd*	...	1	5	5
300....	4812.25	4812.20	*Ti, Sr*	00	1d	1, 20	2, 10
250....	4813.28	4813.30	–	0	0	...	...
300....	4813.66	4813.66	*Co*	1	2	8	10
250....	4814.02	....	...	...	0	...	...
300....	4814.74	4814.78	*Ni*	00	1	1	1
300....	4815.92	(4815.90)	*Zr-Sa*	...	1d	10-6	3-4
250....	4816.60	....	...	...	0	...	...
400....	4817.89	4817.99	*Ni*	2	1N	2	1
350....	4820.57	4820.59	*Ti-Er-Nd*	1	2	8-8-4	3-4-3
250....	4821.81	....	...	...	0	...	...
750....	4823.63	4823.70	*Mn*	5	5	30	10
750....	4824.27	4824.32	*Cr-La*	3	5	2-5	L10-4
500....	4825.65	4825.66	*Nd*	(3) 0	3	8	8
300....	4827.07	4827.03	*Mn-La*	000	0	1-1	1-1
300....	4827.68	4827.64	*V*	000	1d	8	5
250....	4828.55	....	...	...	0	...	...
350....	4829.29	4829.35	*Ni, Cr*	(2) 5	2d	10, 5	3, 3
400....	4831.26	4831.36	*Ni-Er*	3	1	5-5	3-3

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
300....	4832.72	4832.62	*V*	00	1d	3	3
		4832.90	*Fe-Ni*	3		1-3	–1
400....	4836.13	4836.06	*Fe, Nd*	2	2	1, 3	–, 2
300....	4836.99	4837.04	*Cr*	00	1	2	1
350....	4838.72	4838.74	*Ni, Fe*	(2) 3	1	3, 1	2, –
300....	4839.73	4839.73	*Fe*	3	1	1	1
300....	4840.42	4840.45	*Co*	2	2	10	10
350....	4841.00	4841.07	*Ti*	3	1	10	4
300....	4843.01	4842.98	*Fe*	1	0	...	...
300....	4843.46	4843.42	*Fe-Co*	(2) 3	1d	1-3	1–
350....	4844.28	4844.21	*Ti-Fe*	1	0	1–	1–
350....	4848.56	4848.48	*Cr-Ti*	(2) 2	2d	1–	L8–
350....	4849.33	4849.36	–	0	2	...	...
350....	4851.67	4851.69	*V*	1	1	10	8
300....	4852.77	4852.74	*Ni*	2	1	2	1
350....	4855.00	4855.06	*Y*	1	3 ?	10	L30
300....	4855.55	4855.60	*Ni*	3	1	10	3
300....	4856.18	4856.20	*Ti*	1	0	8	5
350....	4857.51	4857.58	*Ni*	1	1	3	1
350....	4859.20	4859.22	*Nd*	000	1	5	5
350....	4859.95	4859.93	*Fe-Y*	4	1	6-8	2-3
8000....	4861.90	4861.53	H_β	30	100	...	...
350....	4864.50	4864.50	*Cr*	1	1	...	L5
300....	4864.89	4864.92	*V*	0	1	10	8
350....	4865.70	4865.80	*Ti*	1	0	...	1
350....	4866.60	....	...	...	1N	...	...
350....	4868.20	4868.19	*Co, Ti*	(2) 2	2d	10, 8	10, 3
300....	4870.37	4870.32	*Ti*	1	0	8	3
350....	4870.98	4871.00	*Ni, Cr*	3	0	3, 3	1, 2
400....	4871.54	4871.51	*Fe*	5	3	8	4
400....	4872.35	4872.33	*Fe*	4	3	8	3
400....	4873.63	4873.63	*Ni*	2	1	8	2
400....	4874.16	4874.20	*Ti*	0	1	...	L3
350....	4875.69	4875.67	*V*	1	1	10	10
350....	4876.59	4876.59	*Cr*	1	2	...	L5
350....	4877.75	4877.77	–	0	0	...	...
500....	4878.36	4878.37	*Cr, Fe*	(2) 7	3d	20, 6	8, 2
400....	4881.75	4881.74	*V*	1N	2	10	10
350....	4882.36	4882.34	*Fe*	3	1	1	1
600....	4883.93	4883.87	*Y*	2	6	15	L50
300....	4884.84	4884.78	–	0	1	...	...
300....	4885.25	4885.26	*Ti*	2	1	10	5
300....	4885.61	4885.62	*Fe*	3	0	1	1
300....	4886.18	4886.13	*Cr*	00	0	1	1
350....	4886.55	4886.52	*Fe-Er*	3	1	1-3	1-1
350....	4887.29	4887.28	*Cr-Ni-Fe*	(2) 4	2d	3-2-1	3-1–
350....	4888.79	4888.82	*Fe*	2	1	1	1
400....	4889.28	4889.23	*Fe–*	(2) 5	2	1–	1–
600....	4890.96	4890.95	*Fe*	6	5	8	4
600....	4891.72	4891.68	*Fe*	8	6	10	5
300....	4893.10	4893.03	*Fe*	1	1	1	...

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
300....	4894.03	4894.00	–	00	1d?	...	...
250....	4894.78	4894.74	–	00	0	...	...
300....	4896.68	4896.62	*Fe*	1	0	...	...
600....	4900.32	4900.30	*Y*	2	10	10	L30
250....	4901.83	4901.81	*V*	00	0	3	5
300....	4902.46	4902.42	–	00	1N	...	...
350....	4903.47	4903.50	*Fe*	5	2d	5	2
350....	4904.56	4904.60	*V, Ni*	3	2	5, 10	8, 3
300....	4905.33	4905.31	*La*	0	1	1	...
300....	4906.28	4906.32	*Y*	000	0	3	2
300....	4907.68	4907.68	*Fe, Eu*	0000	0d?	1-8	–2
300....	4908.20	4908.21	–	0N	0	...	...
300....	4908.73	4908.73	*Co–*	(²) 0	0	1–	...
300....	4909.44	4909.49	*Ti, Fe*	(²) 2	0d	1, 1	1–
350....	4910.05	....	...	...	0	...	...
350....	4910.50	4910.50	*Fe*	2	1	1	...
350....	4910.79	4910.75	*Fe*	2	1	1	1
350....	4911.35	4911.37	*Ti*	1	1	...	L5
300....	4912.15	4912.20	*Ni*	1	0	3	1
250....	4913.38	4913.36	–	(²) 0	0	...	...
300....	4913.76	4913.80	*Ti*	2	1	10	3
300....	4914.17	4914.15	*Ni*	2	1	3	1
350....	4917.42	4917.41	*Fe*	2	1	1	...
350....	4918.55	4918.54	*Ni*	2	2	3	2
400....	4919.20	4919.17	*Fe*	6	3	10	4
350....	4920.02	4920.05	*Ti*	00	1	4	2
500....	4920.68	4920.68	*Fe*	10	4	15	8
400....	4921.10	4921.15	*La*	0	1	5	8
1500....	4922.19	(4922.10)	*He*	...	3d	...	...
1000....	4924.14	4924.11	*Fe*	5	20	...	L8
350....	4925.01	4924.96	*Zn, Fe*	3	0	–, 2	500, 1
350....	4925.78	4925.75	*Ni-V*	1	1	3-3	1-1
300....	4927.18	....	...	...	0	...	...
300....	4927.53	4927.60	*Fe*	1	0	...	...
350....	4928.05	4928.05	*Fe*	2	1	1	...
350....	4928.55	4928.51	*Ti*	0	0	5	3
300....	4930.55	4930.49	*Fe*	2	0N	1	1
350....	4933.49	4933.51	*Fe*	2	1	1	1
750....	4934.26	4934.25	*Ba*	7d	12	100	300
300....	4935.95	4936.02	*Ni*	2	0	5	2
300....	4936.42	4936.51	*Cr*	1	0	3	1
300....	4937.59	4937.52	*Ni*	3	0	5	1
300....	4938.30	4938.35	*Fe*	2	0	1	1
350....	4939.02	4938.98	*Fe*	4	0	3	1
300....	4939.42	4939.42	*Fe*	2	0	1	...
350....	4939.83	4939.87	*Fe*	3	1	2	1
300....	4940.35	....		...	0	...	...
350....	4942.67	4942.66	*Cr*	2	0	3	1
300....	4944.47	4944.47	*Er*	00	0	3	1
300....	4945.72	4945.72	*Ni-Fe*	(²) 2	1d	2–	...
350....	4946.59	4946.57	*Fe-La*	3	2	2-2	1-1

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
300....	4949.16	....	...	...	0	...	...
350....	4950.27	4950.29	*Fe*	2	1	1	...
350....	4952.32	....	...	...	0	...	...
350....	4952.81	4952.82	–	2	0	...	...
300....	4953.38	4953.39	*Ni*	2	1	3	1
350....	4954.87	4954.92	*Cr-Fe*	(²) 3	1d	3–	2–
500....	4957.68	4957.67	*Fe*	(²) 13	8d	15	11
300....	4958.41	4958.43	*Ti*	00	0	1	1
400....	4959.25	(4959.28)	*Nd*	...	1d	4	2
250....	{4961.68	....	...	...	0	...	...
250....	{4962.75	4962.75	*Eu*	2	0	3	2
250....	{4963.64	....	...	...	0	...	...
250....	4964.88	4964.90	*Ti*	000	0	1	1
250....	4965.40	4965.35	*Ni*	0	0	1	...
350....	4966.33	4966.27	*Fe-V*	4	1	2-2	2-1
350....	4968.03	4968.08	*Fe*	3	2	1	...
350....	4968.80	4968.84	*Fe, Ti*	(²) 2	2	–1	–1
350....	4970.05	4970.10	*Fe*	3	2	1	...
300....	4970.59	4970.67	*Fe-La*	1	1	–3	–2
300....	4971.53	4971.53	*Ni*	1	1	3	1
400....	4973.20	4973.28	*Ti-Fe*	4	2d	2-1	2-1
300....	4974.60	4974.64	*C*	0000	0d	...	...
300....	4975.60	4975.56	*Ti-Fe*	(²) 0	1d	3–	3–
300....	4976.37	4976.44	*Ni*	(²) 1	0	2	...
250....	4978.38	4978.37	*Ti*	00	0	2	2
300....	4978.76	4978.78	*Fe*	3	1	1	1
300....	4979.34	4979.39	*C*	000	0	...	...
250....	4979.80	4979.77	*Fe*	00	0	...	...
300....	4980.35	4980.35	*Ni*	4	1	10	2
350....	4981.89	4981.91	*Ti*	4	2	20	10
300....	4982.69	4982.68	*Fe*	4	0d	3	1
300....	4983.56	{4983.43 {4983.64	*Fe* *C*	3 0000	1d?	1 ...	1 ...
350....	4984.14	4984.14	*Ni-Fe*	(²) 5	2d	10-2	2-1
350....	4985.47	4985.43	*Fe*	3	1	1	1
350....	4985.77	4985.73	*Fe*	3	1	1	1
250....	4986.46	4986.40	*Fe*	1	0	...	...
300....	4986.80	....	...	...	0	...	...
300....	4988.31	4988.31	*C*	000	1	...	...
350....	4989.17	4989.13	*Fe*	2	2	1	...
400....	4991.29	4991.25	*Ti*	3	3	20	10
400....	4993.65	4993.70	–	(²) 1	1d?	...	...
500....	4994.25	4994.32	*Fe*	3	1	2	1
250....	4995.70	4995.71	–	(²) 0	0N	...	...
350....	{4996.85	....	...	...	0	...	...
350....	{4997.29	4997.28	*Ti*	0	1	3	1
350....	4998.40	4998.41	*Ni*	1	0	2	1
400....	4999.67	4999.69	*Ti-La*	3	2d	20-5	10-3
350....	5000.50	5000.53	*Ni*	2	0	...	1
350....	5001.22	5001.16	*Ti-C*	0	0	3	2
400....	5002.02	5002.04	*Fe*	5	3	4	2

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
300....	5002.83	(5002.80)	*V-Ce-C*	2	0d	3-1-	3-1-
350....	5003.90	5003.92	*Ni*	0	1d	2	...
350....	5005.39	5005.35	*Mn*	0	0	...	...
400....	5005.86	5005.90	*Fe*	4	2	2	1
400....	5006.31	5006.31	*Fe*	5	2	5	2
350....	5007.41	5007.42	*Ti-Fe*	5d	2d	20-1	10-2
350....	5009.90	5009.83	*Ti*	00	0	2	1
400....	5010.43	5010.40	*Ti*	00	1	...	1
500....	5011.12	5011.12	*Ni*	0	1	3	...
350....	5011.67	....	*C*	...	0	...	...
500....	5012.25	5012.25	*Fe*	4	2	5	2
350....	5012.67	5012.63	*Ni*	1	0	4	1
350....	5013.32	5013.33	*Ti-Cr*	([2]) 3	1	4-	3-
350....	5013.85	5013.87	*Ti*	0	1	...	1
350....	5014.43	5014.42	*Ti-Ni*	([2]) 5	1	20-3	8-
350....	5015.16	5015.12	*Fe*	3	0	2	1
1600....	5015.86	(5015.73)	*He*	...	2	...	...
350....	5016.32	5016.34	*Ti*	2	0	10	5
600....	5017.20	....	...	...	0	...	...
350....	5017.70	5017.76	*Ni*	3	0	8	2
1200....	5018.61	5018.63	*Fe*	4	15	1	L7
350....	5019.94	5019.91	*V-La-*	00	0	1-1	3-
400....	5020.20	5020.21	*Ti*	2	1	10	5
300....	5020.96	5021.00	–	00	0	...	...
300....	5021.85	5021.87	*C*	000	0	...	...
350....	5022.44	5022.41	*Fe*	3	2	1	1
500....	5023.05	5023.05	*Ti*	2	2	10	5
300....	5023.37	5023.37	*Fe?*	0	0	...	...
300....	5023.72	5023.67	*Fe, Sa*	0	0	-2	-1
300....	5024.30	(5024.34)	*C*	...	0	...	...
300....	5025.00	5025.03	*Ti*	3	1	10	3
300....	5025.70	5025.75	*Ti*	1	1	10	3
350....	5027.36	5027.30	*Fe*	3	2	1	1
300....	5028.13	5028.18	*Fe-C*	([2]) 3	0d	...	...
300....	5029.79	5029.80	*Fe*	1	1	...	...
600....	5031.18	5031.20	*Sc-C*	3	5	5	4
300....	5032.10	5032.09	–	00	0	...	...
300....	5032.98	5032.91	*Ni*	00	0	2	...
300....	5033.76	5033.77	*C-Eu*	([2]) 0	0	-3	-1
500....	5035.58	5035.54	*Ni*	5	1	20	3
500....	5036.09	5036.12	*Ti-Ni*	([2]) 5	1	10-5	8-
400....	5036.43	5036.45	*Fe*	0	0	...	...
400....	5036.67	5036.64	*Ti*	2	0	10	8
300....	5037.93	5037.93	*Ce-C*	([2]) 0	0	2-	1-
500....	5038.59	5038.58	*Ti*	2	2	10	8
350....	5039.40	5039.43	*Fe*	3	0	...	...
400....	5040.16	5040.14	*Ti*	3	1	10	3
500....	5041.15	5041.18	*Fe-Ni*	([2]) 7	2	2-2	1-
500....	5041.89	5041.89	*Ca, Fe*	([2]) 6	3d	20, 3	2, 1
400....	5042.36	5042.37	*Ni*	1	1	5	...
300....	5043.76	5043.76	*Ti*	00	0	2	1

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
300....	5044.43	5044.39	*Ni, Co-Fe*	3	1	...	...
300....	5045.56	5045.52	*Ti-C*	(²) 0	0	...	...
350....	5048.21	5048.24	*Ni*	0	0	2	...
400....	5048.64	5048.61	*Fe*	3	1	...	...
400....	5049.06	5049.04	*Ni*	2	1	5	1
600....	5050.03	5050.01	*Fe*	6	2	4	2
300....	5050.88	5050.92	*C*	000	0	...	...
600....	5051.84	5051.82	*Fe-V*	4	2d	3-2	1-2
400....	5053.09	5053.06	*Ti*	0	1d	2	2
300....	5055.10	....	...	...	0	...	...
350....	5056.30	5056.31	*C*	000	0N	...	...
300....	5057.00	5057.02	*Fe*	1	0	...	...
300....	5057.99	5058.02	–	000	0	...	...
400....	5060.25	5060.26	*Fe*	3	1	1	...
300....	5062.29	5062.28	*Ti*	0	0	2	1
300....	5063.33	5063.36	*C*	00	0	...	...
450....	5064.74	5064.72	*Ti*	(²) 3	1	11	6
500....	5065.26	5065.26	*Fe*–	(³) 6	2	7	...
300....	5066.26	....	...	...	0	...	...
300....	5067.39	5067.34	*Fe*	3	1	1	...
300....	5067.88	5067.87	*Cr*	0	0	...	...
500....	5068.91	5068.94	*Fe-C*	5	1	4–	1–
400....	5070.18	5070.16	*C*–	00	2N	...	...
300....	5070.81	....	...	...	0	...	...
300....	5071.66	5071.67	*Ti*	0	1	3	2
400....	{5072.21	{5072.26	*Fe*	3	2	1	...
400....	{5072.52	{5072.48	*Ti*	0	0	...	L3
300....	{5072.81	{5072.85	*Fe*	2	0	1	...
300....	5073.60	5073.64	*C*	00	0	...	...
450....	5074.93	5074.93	*Fe*	5	2	8	1
300....	5075.69	....	...	...	0	...	...
400....	5076.40	5076.45	*Fe*	3	1	1	...
400....	5076.78	5076.81	*Nd-C*	0	0	3–	2–
500....	5079.27	5079.30	*Fe*	(²) 7	3d	5	2
400....	5080.02	5079.97	*Fe-Ni*	(²) 5	2d	2-2	1–
400....	5080.76	5080.71	*Ni*	4	1	8	3
400....	5081.26	5081.29	*Ni*	3	1	8	3
300....	5081.90	5081.85	*Sc-C*	(²) 0	0	...	2–
300....	5082.74	....	...	...	1d?	...	...
400....	5083.54	5083.52	*Fe*	4	2	3	1
400....	{5084.30	5084.28	*Ni*	3	2	5	3
300....	{5084.71	5084.73	–	000	0	...	...
300....	5086.16	....	...	...	0	...	...
350....	5087.21	5087.24	*Ti*	0	0	3	2
500....	5087.62	5087.60	*Y*	1	3	10	10
300....	5088.45	5088.52	*Y-Ni-C*	(²) 1	0d	...	...
450....	5089.39	5089.39	*C*	000Nd?	2d?	...	...
450....	5090.96	5090.95	*Fe-C*	5	2	2	1
300....	5092.62	(5092.60)	*C*	...	1d	...	...
300....	5095.34	5095.35	*C*–	00	0d	...	...
300....	5096.08	5096.03	...	000	0	...	...

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
300....	5096.82	5096.91	*C*	000	0	...	...
400....	5097.18	5097.17	*Cr-Fe*	3	1	-2	L2-1
300....	5098.29	5098.30	*C*	00N	0	...	...
400....	5098.89	5098.88	*Fe*	3	1	4	1
400....	5099.39	5099.42	*Ni-Fe*	(2) 1	0	4-1	1-
400....	5100.03	5100.11	*Ni*	2	1	8	1
350....	5100.99	5101.03	*C*	000	0N	...	...
300....	5103.79	....	...	...	0	...	...
300....	5104.40	5104.39	*Fe*–	(3) 1	0N	...	...
350....	5105.42	5105.38	*Y-Nd*	(3) 0	0	2-2	3-1
400....	5105.70	5105.72	*Fe-Cu-Co*	4	2	1-50-3	-20-
400....	5106.61	5106.62	*C*	000	1N	...	...
500....	5107.75	5107.72	*Fe*	(2) 8	3d	4	2
400....	5109.76	5109.83	*Fe*	2	0N	1	...
600....	5110.63	5110.57	*Fe*	5d	2	3	1
300....	5110.91	5110.94	*Cr-C*	00	0	1	...
300....	5111.50	5111.48	*C*	(2) 00	0	...	...
350....	5111.83	5111.80	*C*	000	1	...	...
300....	5112.41	5112.46	–	000	1	...	...
300....	5112.90	5112.88	–	(2) 00	0	...	...
350....	5113.26	5113.25	*Cr-C*	(2) 0	1	1-	...
350....	5113.64	5113.62	*Ti*	0	1	4	2
350....	5114.62	5114.56	*La-C*	(2) 00Nd?	1d	4-	3-
400....	5115.58	5115.57	*Ni*	2	2	10	2
350....	5116.34	5116.36	–	0000	0	...	...
350....	5116.84	5116.85	*C*	0000	1	...	...
350....	5117.10	5117.07	–	000	1	...	...
350....	5118.14	5118.11	*Mn, C*	00	1	2, –	1, –
400....	5118.34	5118.35	*C*	0000	1	...	9
350....	5119.35	5119.29	*Y-C*	00	1	3-	3-
300....	5119.65	....	...	...	0	...	...
350....	5120.60	5120.59	*Ti*	0	1d	5	4
350....	5121.77	5121.80	*Fe-Ni-C*	(2) 3	1d	2-3-	...
300....	5122.50	5122.48	*C*	0000	0	...	...
350....	5123.14	5123.18	*La*	000	2	4	3
400....	5123.35	5123.39	*Y*	0	1	4	4
400....	5123.90	5123.90	*Fe*	3	2	3	1
350....	5125.30	5125.30	*Fe*	3	2	5	1
300....	5126.18	5126.17	*C*	0000	1	...	...
300....	5126.40	5126.37	*Fe-Co*	2	1	1-3	...
300....	5127.52	5127.53	*Fe-Ti*	3	0	2-1	1-1
300....	5127.99	5128.05	*C*	0000	0	...	...
300....	5128.53	5128.49	*C*	0000	0	...	...
300....	5128.74	5128.73	*V-C*	(2) 00	0	8-	10-
500....	5129.41	5129.42	*Ti-Ni*	(2) 5	3d	1-10	L8-1
350....	5130.44	5130.46	*Ni-C*	(2) 0	0	...	...
350....	5130.73	5130.76	*Nd-C*	000	2	5-	4-
350....	5131.66	5131.64	*Fe-C*	2	2	2	...
400....	5131.92	5131.94	*Ni-C*	1	2	4-	...
350....	5132.72	5132.72	*C*	(3) 0	1d	...	...
400....	5133.82	5133.87	*Fe-C*	4	3	15	2

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
350....	5134.64	5134.68	*C*	(3) 0	0d	...	...
300....	5135.35	5135.36	–	0000	0	...	...
300....	5135.82	5135.82	*C*	(2) 00	0N	...	...
300....	5137.23	5137.25	*Ni*	3	1	8	1
350....	5137.59	5137.56	*Fe*	3	2	10	1
350....	5138.55	5138.52	*V-C*	0000	1	8–	10–
350....	5139.42	5139.43	*Fe-C*	4	0	3–	2–
500....	5139.60	5139.64	*Fe-V*	4	4	8-3	3-3
300....	5139.82	5139.82	*Cr*	00	0	2	...
350....	{5141.17	5141.19	–	0000	0	...	...
350....	{5141.40	5141.44	*C*	(2) 00	0	...	...
350....	{5141.92	5141.92	*Fe*	3	1	2	1
500....	5142.67	5142.69	*Fe*	4d?	3	2	1
400....	5143.05	5143.05	*Ni-Fe-C*	5	2	15-2-	1–
350....	5144.74	5144.76	*C–*	000	0d	...	...
350....	5145.51	5145.56	*Ti-La-C*	(2) 1	1N	5-3-	3-1-
500....	5146.48	{5146.29	*C*	00}	3d	{...	...
		{5146.66	*Ni-C*	3}		{20	2–
500....	{5147.78	5147.79	*C-Ti*	(3) 1	2	...	...
500....	{5148.30	5148.33	*Fe*	(2) 5	2	5	1
400....	5149.30	5149.27	*C*	000	1	...	...
350....	5150.35	5150.36	*C–*	00	0	...	...
400....	5150.89	{5150.74	*C*	000}	2d	{...	...
		{5151.02	*Fe*	4}		{2	1
400....	5152.05	5152.09	*Fe-C*	3	1	2–	1–
400....	5152.38	5152.36	*Ti*	0	0	5	2
400....	5153.30	5153.34	*C*	0000	1	...	...
500....	5154.27	5154.24	*Ti-Co*	2	3	1-3	L4–
400....	5155.68	5155.70	*Ni-C*	(3) 3	2d	13–	1–
400....	5156.70	5156.73	*C*	0000	1	...	...
350....	{5157.78	5157.78	*C*	000	1	...	...
350....	{5158.12	5158.18	*Ni*	00	0	2	...
400....	5158.70	5158.70	*C*	000	1	...	...
400....	5159.60	5159.63	*C*	000	0	...	...
350....	5159.91	5159.95	–	0000	0	...	...
350....	5160.46	5160.42	*C–*	00N	1	...	...
350....	5161.20	5161.19	*C*	000	1	...	...
350....	5161.86	5161.85	*C*	0000	1	...	...
400....	5162.50	5162.45	*Fe, C*	5	2	8, –	1, –
350....	{5163.07	5163.07	*C*	000	0	...	...
350....	{5163.60	5163.58	*C*	000	0	...	...
350....	{5164.43	5164.40	*C*	000	0	...	...
400....	{5164.88	5164.90	*C*	000	0	...	...
500....	{5165.35	{5165.30	*C*	0000}	2	...	...
		{5165.42*	*C*	0000}			
500....	5166.43	5166.45	*Cr-Fe*	3	1	2-2	1-1
700....	5167.54	{5167.50	*Mg*	15}	12	{50	20
		{5167.68	*Fe*	5}		{20	4
300....	5167.94	5167.89	...	00	0	...	...
700....	5169.18	5169.16	*Fe*	(2) 7	15	2	L6

* Head of carbon band.

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
300....	5170.87	5170.94	*Fe*	0	0d	1	...
600....	5171.75	5171.78	*Fe*	6	2	10	2
1000....	5172.82	5172.86	*Mg*	20	20	50	30
500....	5173.92	5173.92	*Ti*	2	2	15	5
300....	5175.58	5175.58	–	000	0	...	...
500....	5176.76	5176.74	*Ni*	1	1	8	1
300....	5177.62	5177.58	*Cr-Co*	00	0	1-1	1–
250....	5178.40	....	...	...	0	...	...
300....	5180.28	5180.23	*Fe*	1	0	1	...
250....	5181.84	....	...	...	0	...	...
1200....	5183.74	5183.79	*Mg*	30	25	100	100
250....	5184.47	5184.44	*Fe*	2	0	1	...
250....	5185.10	....	...	...	0	...	...
500....	5185.97	5186.07	*Ti*	2	2	...	L5
350....	5186.84	....	...	...	0	...	...
300....	5187.40	....	...	...	0	...	...
400....	5187.92	....	...	...	0	...	...
750....	5188.85	5188.86	*Ti*	3	4	2	L10
500....	5191.66	5191.63	*Fe*	4	3	10	2
350....	5192.10	5192.15	*Cr*	00	0	2	1
500....	{5192.60	5192.52	*Fe-Nd*	5	3	10-6	2-2
300....	5193.14}	5193.14	*Ti*	2	0	20	8
300....	5194.19	5194.22	*Ti*	000	0	2	1
400....	5195.15	5195.11	*Fe*	4	3	5	1
350....	5195.65	5195.65	*Fe-V*	2	1	4-3	1-3
300....	5196.26	5196.23	*Fe*	1	0	1	...
350....	5196.63	5196.61	*Cr*	0	1	2	1
500....	5197.73	5197.74	*Fe?*	2	4	1	1
300....	5198.11	5198.11	...	0	0	...	...
400....	5198.90	5198.89	*Fe*	3	1	3	1
400....	5200.45	5200.51	*V-Cr*	(?) 1	2d	10-1	8-1
300....	5201.31	5201.26	*Ti*	000	1	2	1
400....	5202.43	5202.49	*Fe–*	(?) 6	2d	5	1
300....	5203.30	....	...	...	0	...	...
500....	5204.70	5204.71	*Cr-Fe*	(?) 8	3d	20-2	10–
300....	5205.18	....	...	...	0	...	...
600....	5206.06	{5205.90 5206.22}	*V* *Cr-Ti*	0 5	6d	{10 30-2}	10 15-2
300....	5207.72	5207.79	–	000	0	...	...
500....	5208.54	5208.60	*Cr*	5	5	30	20
250....	5209.61	....	...	...	0	...	...
300....	5210.48	5210.56	*Ti*	3	1d	20	10
250....	5211.53	....	...	...	0	...	...
250....	5212.34	5212.40	*V, Cr*	000	0	1, 1	1, –
250....	5212.90	5212.86	*Co*	000	0	8	1
300....	5215.35	5215.35	*Fe*	3	1	6	1
350....	5216.47	5216.44	*Fe*	3	2	6	1
300....	5217.56	5217.55	*Fe*	3	1	5	1
300....	5218.31	5218.27	*Fe, Cu*	(?) 1	1d	1, 200	–, 200
250....	5219.66	(5219.68)	*Ti-Gd*	...	0	3-3	2-1
250....	5220.28	5220.36	*Ni*	0	0d	5	...

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
250....	5221.20	5221.20	*Cr*	00	0	1	...
250....	5222.47	(5222.50)	*Sr*	...	0	20	2
250....	5223.33	5223.35	*Fe*	0	0	1	...
250....	5224.35	5224.29	*Ti-V-Cr*	(^{2}) 1	0	4-5-1	2-
300....	5224.98	5225.03	*Cr-Ti*	(^{3}) 1	0d	5-2	1-1
300....	5225.63	5225.70	*Fe*	2	0	1	...
500....	5226.69	5226.71	*Ti*	2	4	1	L10
500....	5227.20	5227.26	*Fe-Cr*	(^{2}) 8	3	13-1	6-
250....	5227.92	5227.90	–	000	0	...	...
300....	5228.56	5228.55	*Fe*	1	1	1	...
400....	5230.04	5230.03	*Fe*	4	2	5	1
300....	5230.54	....	...	...	0	...	...
400....	5233.15	5233.12	*Fe*	7	2	20	5
500....	5234.80	5234.79	–	2	5	...	...
250....	5235.59	5235.60	*Ni, Fe*	(^{2}) 1	1	4, 2	–, 1
250....	5236.38	5236.37	*Fe*	0	0	1	...
250....	5237.05	....	...	...	0	...	...
350....	5237.47	5237.49	*Cr*	1	2	1	L7
250....	5238.70	5238.74	*Ti, Sr*	000	0	2, 30	2, 3
250....	5239.10	5239.14	*Cr*	00	0	1	...
350....	5239.95	5239.99	*Sc, Nd*	1	2	3, 3	2, 1
250....	5241.04	5241.04	*V*	000	0	3	5
250....	5241.88	....	...	...	0	...	...
250....	5242.66	5242.66	*Fe*	2	1	3	1
250....	5243.98	5243.95	*Fe*	1	0	1	...
250....	5246.88	5246.84	*Ti-*	(^{2}) 00	0	2-	1-
300....	5247.26	5247.23	*Fe*	1	0	1	...
300....	5247.72	5247.74	*Cr*	2	0	8	2
350....	5249.68	(5249.69)	*Nd*	...	2N	8	4
350....	5250.33	5250.38	*Fe*	2	1	1	...
350....	5250.82	5250.82	*Fe*	3	2	3	1
250....	5252.15	5252.15	*Fe*	0	0	1	...
250....	5252.61	....	...	...	0	...	...
250....	5253.70	5253.63	*Fe*	2	0	2	1
350....	5254.93	....	...	...	1	...	...
350....	5255.32	5255.25	*Fe, Cr-Mn*	(^{3}) 4	1N	1, 5-4	–, 2-2
300....	5257.00	5257.10	*Sr*	00	0	50	3
250....	5257.96	5257.90	*Co-*	(^{2}) 0	0	5-	1-
250....	5259.48	....	...	...	1	...	...
250....	5260.13	5260.14	*Ti*	000	0	1	1
300....	5261.86	5261.88	*Ca-Cr*	3	2	10-1	3-1
300....	5262.37	5262.39	*Ca-Ti*	(^{2}) 4	2	10-	3-1
250....	5263.08	5263.06	...	00	0	...	...
350....	5263.56	5263.49	*Fe*	4	1	5	1
300....	5264.04	5264.04	*Fe*	0	0	1	...
350....	5264.37	5264.37	*Cr, Ca*	(^{2}) 7	1	8, 15	3, 3
350....	5264.93	5264.98	*Co*	0	1	1	...
350....	5265.87	5265.85	*Ca-Cr-Ti*	(^{3}) 6	1d	20-3-3	5-2-3
350....	5266.77	5266.74	*Fe*	6	2	15	3
250....	5267.70	5267.74	*V-*	(^{2}) 00	0	...	1

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
300....	5268.61	5268.61	*Ni-Co*	(2) 1	1N	4-4	...
500....	5269.72	5269.72	*Fe*	8d?	8	20	8
500....	5270.49	5270.51	*Fe-Ca*	(2) 7	6	15-30	4-10
300....	5271.46	5271.46	*La*	00	0	4	1
350....	5272.17	5272.17	*Co-Eu*	00	1	2-4	1-1
350....	5273.61	5273.56	*Fe-Nd-Cr*	2	3d	2-5-1	1-3-
300....	5274.39	5274.41	*Ce*	00	1	5	3
300....	5275.18	5275.15	*Fe*	0	1	1	...
300....	5275.42	5275.45	–	1	1	...	...
500....	5276.16	5276.15	*Cr-Fe-*	(3) 6	10	5-1	1-1
250....	5277.48	5277.48	*Zr*	00	0	1	1
300....	5280.05	5280.05	*Fe*	0	0	1	...
300....	5280.62	5280.63	*Co-Fe*	1	1	8-	...
350....	5281.97	5281.97	*Fe*	5	2	8	2
300....	5282.45	5282.49	*Ti-*	(2) 0	0N	2-	1-
350....	5283.81	5283.80	*Fe*	6	2	10	2
400....	5284.29	5284.28	–	1	3	...	...
250....	5285.27	5285.30	*Ni*	0	0	...	...
300....	5288.81	5288.77	*Fe-Ti*	(2) 2	1d	1-1	-1
250....	5289.72	5289.68	*Mn*	000	0	1	...
250....	5292.65	....	...	...	1	...	...
250....	5293.32	5293.34	*Nd*	00	2	10	5
250....	5295.47	5295.48	*Fe*	0	0	...	...
300....	5296.86	5296.87	*Cr*	3	1	4	3
300....	{5297.57	{5297.56	*Cr*	2	1	2	2
350....	{5298.45	{5298.46	*Cr*	4	2	4	4
250....	{5298.99	{5298.96	*Fe-Mn*	0	0	1-1	1-
250....	5300.15	5300.15	*Ti*	00	0	1	1
250....	5300.99	5300.93	*Cr*	2	0	4	2
350....	5302.44	5302.48	*Fe-Nd*	5	2d	8-3	2-2
300....	5303.56	5303.52	*V-La*	(2) 1	1N	1-3	2-3
250....	5306.03	5306.04	*Cr*	0	0	...	1
400....	5307.57	5307.54	*Fe*	3	2	2	1
250....	5308.66	5308.60	*Cr*	0	0	...	L2
250....	5312.57	5312.55	...	(2) 0	0	...	...
250....	5313.02	5313.03	*Cr*	0	0	...	...
250....	5313.74	5313.76	*Cr*	1	1	...	1
250....	5314.41	5314.42	–	000N	0	...	...
250....	5315.24	5315.25	*Fe*	1	0	1	...
850....	5316.83	5316.86	*Fe-Co*	(3) 6	12	-4	L3-
250....	5318.48	5318.53	*Sc*	00	0N	1	...
250....	5318.95	5318.96	*Cr*	0	0	2	1
300....	5320.04	5320.07	*Nd-Fe*	(2) 1	1d?	10-1	4
300....	5321.26	5321.29	*Fe*	2	1	1	...
300....	5322.25	5322.23	*Fe*	3	1	1	...
300....	5323.05	....	...	...	1	...	...
400....	5324.40	5324.37	*Fe*	7	4	20	5
400....	5325.76	5325.74	–	2	3	...	...
250....	5326.63	5326.61	–	(2) 00	0	...	...
500....	5328.20	5328.24	*Fe*	8d?	8	15	6
500....	5328.61	5328.65	*Fe, Cr*	(3) 6	6	8, 10	2, 10

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
350....	5329.36	5329.33	*Cr*	3	0	3	1
350....	5330.14	5330.18	*Fe, Sr*	2	1	2, 20	–, 1
250....	5330.78	5330.75	*Ce*	000	0	4	2
250....	5331.56	5331.64	*Co*	00d	0	4	...
350....	5333.02	5332.98	*Fe, Co*	(²) 5	2d	1, 3	1, –
250....	5335.06	5335.05	*Co*	1	0	3	...
450....	5336.94	5336.97	*Ti*	4	5	1	L10
300....	5337.94	5337.92	*Cr*	(²) 1	2d	...	1
250....	5339.58	5339.61	*Co*	00	0	2	...
250....	5340.16	5340.12	*Fe*	6	2	10	2
450....	5341.28	5341.23	*Fe-Mn-Co*	(²) 8	3d	10-15-5	2-8-
250....	5341.68	5341.67	*Ti*	000	0	1	1
300....	5342.87	5342.89	*Co*	1	2	10	...
300....	5343.64	5343.60	*Co-Fe*	2	2	8-1	...
250....	5344.76	5344.77	*V-Co*	000N	0	1-2	1–
350....	5345.96	5345.99	*Cr*	5	2	20	5
250....	5346.77	5346.73	*Fe*	0	1	...	...
250....	5347.65	5347.71	*Co*	00	0	3	...
350....	5348.52	5348.52	*Cr*	4	1	10	3
400....	5349.64	5349.65	*Ca*	4	2	20	5
350....	5349.88	5349.93	*Fe*	1	1	...	...
300....	5350.34	5350.30	*Zr-Mn*	(³) 1	1	2-3	1-1
300....	5351.18	5351.26	*Ti*	00	0	3	3
250....	5352.18	5352.23	*Co*	1	2N	10	...
500....	5353.60	5353.60	*Fe, Co, Ce, V*	(²) 3	5d	3, 10, 8, 3	1, –, 10, 5
250....	5355.95	5355.92	*Sc*	00	...	2	...
250....	5357.40	5357.38	*Sc*	00	0	1	...
250....	5359.40	5359.39	*Co*	00	0	10	...
350....	5361.76	5361.81	*Fe-Eu*	1	1	1-3	...
500....	5363.05	5363.06	–	3	8	...	...
250....	5364.66	5364.62	–	000	0	...	...
300....	5365.04	5365.07	*Fe*	5	3	20	2
300....	5365.53	5365.60	*Fe*	3	3	3	1
300....	5366.79	5366.83	*Ti*	000	0d ?	1	1
350....	5367.64	5367.67	*Fe*	6	3	20	2
250....	5368.41	5368.40	–	(²) 0	0d	...	...
300....	5369.81	5369.78	*Co-Ti*	1	1	10-2	–2
350....	5370.16	5370.17	*Fe*	6	3	20	3
500....	5371.69	5371.69	*Fe*	(²) 7	8	15	6
250....	5372.73	....	...	...	0	...	...
300....	5373.82	5373.90	*Fe, Cr*	2	1d ?	2, 1	–, 1
300....	5377.80	5377.80	*Mn*	2N	2	10	3
300....	5379.70	5379.78	*Fe*	3	2	2	1
250....	5380.54	5380.52	–	0N	0	...	...
400....	5381.23	5381.22	*Ti-La*	2	4	–3	L4-1
250....	5382.26	....	...	...	0N	...	...
400....	5383.50	5383.58	*Fe*	3	3	50	6
250....	5385.75	5385.78	–	00	0	...	...
250....	5388.55	5388.55	*Ni, V*	00	0	2, 3	–, 2
350....	5389.67	5389.68	*Fe*	3	2	8	1

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
250....	5390.03	5390.05	–	00	0	...	...
300....	5390.50	5390.55	*Ti, Co, Cr*	(3) 1	1d	2, 2, 1	2, –, 1
350....	5391.61	5391.66	*Fe*	2	2	3	1
350....	5391.84	5391.82	*Fe*	1	1	3	1
250....	5392.18	5392.21	*Sc*	00	0	3	...
400....	5393.39	5393.38	*Fe*	5	3	10	2
350....	5393.65	(5393.62)	*Ce*	...	2	5	3
350....	5394.86	5394.88	*Mn*	2	2d	8	1
250....	5395.37	5395.42	*Fe*	0	0	1	...
250....	5396.47	5396.45	*Ti*	00	0	...	1
800....	5397.34	5397.34	*Fe-Ti*	7d?	6	15-2	6-2
300....	5397.85	5397.82	*Fe?*	1	0	...	...
350....	5398.46	5398.49	*Fe*	3	2	3	...
350....	5399.62	5399.68	*Mn*	1d?	1d?	10	2
400....	5400.65	5400.71	*Fe*	3	3	10	1
250....	5401.77	....	...	...	0	...	...
300....	5402.19	(5402.18)	*V-Co*	...	1d	8-4	10–
350....	5402.96	5402.98	*V*	0	1	4	8
300....	5403.97	5404.03	*Fe*	2	1	50d?	6
450....	5404.31	5404.36	*Fe*	5	6		
300....	5405.58	5405.55	–	1	1	...	...
600....	5406.04	5405.99	*Fe*	6	8	15	6
300....	5407.00	5406.98	–	1	1	...	...
450....	5407.70	5407.64	*Mn*	(2) 1	2d	10	2
300....	5409.36	5409.34	*Fe*	2	1	1	...
350....	5410.01	5410.00	*Cr*	4	2	20	8
400....	5411.09	5411.12	*Fe*	4	4	20	3
300....	5411.44	5411.43	*Ni*	1	1	8	1
250....	5413.43	(5413.43)	*Co*	...	0	3	...
300....	5414.24	5414.28	–	00	1	...	...
400....	5415.43	5415.42	*Fe-V*	5	3	50-10	6-10
250....	5417.25	5417.25	*Fe*	0	0	1	...
250....	5418.35	5418.41	–	(2) 00	0	...	...
400....	5419.00	5418.98	*Ti*	1	4d?	...	L4
250....	5419.49	....	...	...	1d?	...	...
400....	5420.49	5420.56	*Mn-V*	1N	2	10-2	3-2
300....	5421.14	5421.13	*Cr*	00	1	...	1
350....	5424.27	5424.29	*Fe-V*	6	5	100-5	8-5
300....	5424.85	5424.86	*Ni-Ba*	1	2	5-50	1-3
350....	5425.50	5425.46	–	1	4	...	...
250....	5427.44	5427.43	*Mn?*	0000	0	1	...
600....	5429.93	5429.91	*Fe*	6d?	10	20	6
250....	5430.56	5430.57	*Ni*	00	0	1	...
300....	5431.80	5431.75	*Nd*	000	1	4	3
350....	5432.60	....	...	...	1d?	...	...
400....	5433.10	5433.16	*Fe*	2	3	1	...
250....	5433.85	5433.84	–	00N	0	...	...
500....	5434.74	5434.74	*Fe*	5	5	15	5
350....	5435.99	5436.07	*Ni*	2	1	8	1
350....	5436.52	5436.51	*Fe*	1	1	1	...
350....	5436.83	5436.80	*Fe*	1	1	1	...

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
250....	5437.40	5437.41	–	00	0	...	...
250....	5438.48	5438.51	*Y, Ti*	000	0	5, 1	2, 1
250....	5441.52	5441.55	*Fe*	1	0	1	...
250....	5442.78	....	...	...	0	...	...
250....	5444.76	5444.80	*Co*	00	1	15	...
350....	5445.23	5445.26	*Fe*	4	3	20	2
500....	5447.06	5447.06	*Fe-Ti*	(²) 8	7d?	20-1	6-1
300....	5448.60	5448.58	*Fe*	00	1	1	...
300....	5451.27	(5451.25)	*Sr, Nd*	...	0	20, 4	2, 3
300....	5452.26	5452.31	*Ti*	00	0	...	1
250....	5453.38	5453.44	*Ni*	00	0	2	...
250....	5454.18	5454.20	...	00	0	...	...
300....	5454.80	5454.78	*Cr*	00	0	10	...
500....	5455.79	5455.78	*Fe*	(²) 6	8	50	6
350....	5460.70	5460.72	*Ti*	00	0N	1	2
300....	5462.75	5462.70	*Ni*	1	1	5	...
350....	5463.15	5463.17	*Fe*	3	2	8	1
400....	5463.46	5463.49	*Fe*	3	3	10	1
300....	5464.35	5464.39	*Cr-Fe*	(²) 1	1d	–1	L2-1
300....	5466.61	5466.61	*Fe-Y*	3	2	4-10	1-3
250....	5467.17	5467.20	*Fe*	1	1	1	...
250....	5467.64	5467.61	–	000	0	...	...
250....	5468.05	5468.07	*V–*	(²) 00	0	1	1
250....	5468.67	5468.60	*Ce, Er, Y*	000d?	0	4, 4, 4	3, 1, 2
250....	5469.77	....	...	...	1d	...	...
300....	5470.30	5470.30	*Fe*	00	0	...	...
300....	5470.84	5470.84	*Mn*	(²) 1	2	10	2
300....	5471.47	5471.41	*Ti-V*	000	0	2-2	2-3
400....	5472.82	....	...	...	1	...	...
300....	5473.57	5473.59	*Y*	000	0	3	3
450....	5474.09	5474.11	*Fe*	3	2	5	1
400....	5476.47	5476.50	*Fe*	1	2	3	1
500....	5476.96	5476.99	*Fe, Ni*	(²) 8	8	8, 30	1, 10
250....	5477.91	5477.90	*Ti*	00	1	3	4
250....	5478.67	5478.67	*Fe*	0	0	...	...
250....	5480.22	5480.18	–	000	0	...	...
250....	5480.96	5480.95	*Fe-Cr*	(²) 1	2d	2-2	1-1
300....	5481.58	5481.55	*Fe-Mn-Ti*	(²) 2	1d	4-8-2	-1-3
250....	5482.05	5482.08	*Ti*	00	0	1	2
350....	5483.42	5483.43	*Fe, Co*	(²) 2	2d	2, 10	...
250....	5485.26	5485.27	*Nd*	0000	0	3	2
250....	5485.83	(5485.86)	*Nd*	...	1	8	4
300....	5487.34	5487.35	*Fe*	1	1	1	...
300....	5487.74	5487.72	–	00N	0	...	...
350....	5487.98	5487.96	*Fe*	3	3N	6	1
300....	5489.95	5489.98	*Co–*	(²) 0	1	5–	...
250....	5490.31	5490.37	*Ti*	0	0	3	4
350....	5490.92	5490.92	–	0	2	...	...
250....	5492.10	5492.05	*Fe*	00	0d	1	...
250....	5494.65	5494.68	*Fe*	0	0N	1	...
500....	5497.61	5497.62 5497.74	*Cd, Y* *Fe*	0000 5	8	–, 5 8	50, 8 2

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
250....	5499.75	5499.80	–	00	0	...	...
400....	5501.67	5501.68	*Fe*	5	5	8	2
250....	5502.24	5502.30	*Cr*	00	0	...	1
300....	5503.22	5503.29	*Fe*	1	2	1	...
300....	5503.65	5503.71	*Y*	00N	0	8	2
300....	5504.18	5504.18	*Ti-Ni*	([2]) 1	1	3-2	8–
300....	5506.04	5506.10	*Mn*	1	1	8	1
400....	5507.01	5507.00	*Fe*	5	5	8	2
350....	5508.76	5508.73	*Cr–*	([2]) 1	2	...	L3
400....	5510.16	5510.19	*Ni-Y*	([2]) 2	4	6-8	–4
350....	5510.82	5510.83	–	00	2	...	...
250....	5511.62	5511.64	–	000	0	...	...
300....	5512.47	5512.47	*Fe*	1	1	1	1
350....	5512.72	5512.74	*Ti*	2	2	5	10
350....	5513.20	5513.20	*Ca*	4	1	8	2
350....	5514.49	5514.56	*Ti*	2	2	3	8
350....	5514.77	5514.75	*Ti*	2	2	3	8
250....	5515.87	5515.86	–	00	0	...	...
250....	5516.55	....	...	...	0	...	...
350....	5516.94	5516.99	*Mn*	([2]) 1	2	10	2
250....	5517.25	5517.29	*Fe*	0	0	...	...
250....	5517.76	5517.76	–	00	0	...	...
250....	5518.32	5518.31	–	000	0	...	...
250....	5521.14	5521.16	–	00N	0	...	...
300....	5521.46	5521.43	–	([2]) 0	1	...	...
300....	5521.84	5521.80	*Y*	00	0	5	3
350....	5522.65	5522.66	*Fe*	2	2	2	1
350....	5525.81	5525.76	*Fe*	2	2N	2	1
600....	5527.10	5527.03	*Sc*	3	10	8	3
250....	5527.80	5527.80	*Y*	000	0	10	3
400....	5528.61	5528.64	*Mg*	8	6d?	10	5
300....	5529.29	5529.25	*Fe–*	([2]) 0	0N	...	...
400....	5531.01	5531.00	*Co*	00N	3	10	1
300....	5533.06	5533.01	*Fe–*	([2]) 2	1N	1	...
300....	5533.91	....	...	...	0d	...	...
600....	5535.06	5535.06	*Sr*	2	8	20	3
400....	5535.62	5535.68	*Fe, Ba*	2	1	3, 100	2, 30
250....	5536.52	5536.49	–	000	0	...	...
350....	5537.95	5537.97	*Mn*	([2]) 0	1	10	1
350....	5538.71	5538.74	*Fe*	1	0	...	...
300....	5539.46	5539.51	*Fe*	0	0	1	...
300....	5540.29	(5540.30)	*Sr*	...	0	20	3
350....	5543.42	5543.41	*Fe, Sr*	2	2	3, 30	1, 1
350....	5544.21	5544.16	*Fe*	2	1	3	1
350....	5544.87	5544.83	*Y*	000	0	4	2
300....	5546.77	5546.73	*Fe*	2	0	2	...
350....	5550.04	5550.c2	–	([2]) 0	0	...	...
300....	5552.17	5552.17	*Mn*	000	0	3	1
350....	5553.82	5553.80	*Fe*	1	1	1	...
250....	5554.54	....	...	...	0	...	...
400....	5555.13	5555.12	*Fe*	3	3	6	2

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
250....	5555.80	....	...	...	oN	...	...
250....	5556.65	....	...	...	o	...	...
350....	5558.13	5558.17	*Fe*–	(?) 1	2	2	...
250....	5559.00	(5559.00)	*V-Co*	...	od	2-3	3-1
300....	5559.93	5559.87	–	00	o	...	...
300....	5560.38	5560.43	*Fe*	2	1	2	...
250....	5561.42	5561.46	*Nd*	00	o	2	1
250....	5561.87	(5561.88)	*V*	...	o	2	2
350....	5562.96	5562.93	*Fe*	2	2	2	...
500....	5563.80	5563.82	*Fe*	3	3	3	1
250....	5564.68	....	...	...	o	...	...
500....	5565.92	5565.93	*Fe*	3	5	6	1
250....	5566.32	5566.30	–	00	1	...	...
400....	5567.58	5567.62	*Fe*	2	3	2	...
500....	5569.91	5569.85	*Fe*	6	6	10	2
500....	5573.08	5573.11	*Fe*	(?) 7	7d	20	3
500....	5576.29	5576.32	*Fe*	4	4	10	1
300....	5577.25	5577.25	*Eu*	00	o	10	1
500....	5578.90	5578.95	*Ni*	1	4	5	...
600....	5582.24	5582.20	*Ca, Y*	4	1	10, 8	3, 2
250....	5583.17	5583.19	*Ti*	000	o	...	1
400....	5585.28	....	...	...	1N	...	...
750....	5587.04	5586.99	*Fe*	7	5	30	4
300....	5587.80	5587.80	*Fe*	o	1	...	...
400....	5588.07	5588.08	*Ni*	1	2	5	1
750....	5588.95	5588.98	*Ca*	6	4	20	10
300....	5589.59	5589.58	*Ni*	o	o	4	1
400....	5590.31	5590.34	*Ca*	3	1	8	3
400....	5591.06	5591.04	*Co*	000	1	8	1
400....	5592.49	5592.49	*Ni-Co*	1	4	8-2	2–
400....	5593.87	5593.96	*Ni*	o	2	8	1
500....	5594.79	5594.73	*Ca, Fe*	(?) 5	4	20, 3	8, –
300....	5596.40	5596.40	–	000	oN	...	...
250....	5597.70	....	...	...	o	...	...
500....	5598.64	5598.67	*Ca, Fe*	(?) 5	4	20, 5	8, 1
250....	5599.75	....	...	...	1	...	...
400....	5600.20	5600.24	*Ni*	00	1	4	...
400....	5600.45	5600.45	*Fe*	o	2	1	...
500....	5601.52	5601.50	*Ca-Ce*	3	2	10-4	3-1
500....	5603.13	5603.14	*Ca, Fe*	(?) 7	5	10, 10	3, 1
350....	5603.84	....	...	...	1	...	...
250....	5607.87	5607.89	–	00	o	...	...
350....	5610.35	5610.34	*Ce*–	(?) 00	o	3–	1–
250....	5611.81	5611.86	–	000	o	...	...
250....	5614.80	....	...	...	o	...	...
500....	5615.87	5615.88	*Fe*	6	8d	50	4
300....	5617.44	5617.41	*Fe*	(?) o	1	1	...
250....	5618.87	5618.86	*Fe*	1	1	2	...
250....	5619.85	5619.82	–	o	1	...	...
250....	5620.73	5620.72	*Nd-Fe*	o	1N	10-1	8–
250....	5623.20	5623.18	*Ce*	00	1	1	1

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
350....	5624.24	5624.24	*Fe*	1	1	1	...
400....	5624.76	5624.77	*Fe*	4	3	10	1
350....	5625.61	5625.66	*Ni*–	(²) 1	2d?	8	1
250....	5626.90	5626.92	*Er-Ce*	(²) 00	0	3-1	1–
300....	5627.82	5627.86	*V*	00	1	10	10
250....	5628.20	5628.24	–	000	0	...	...
250....	5628.70	5628.71	*Cr, Ni*	(²) 0	0d	3, 2	2, –
250....	5632.07	5632.06	–	(³) 0	0d	...	...
350....	5634.17	5634.17	*Fe*	3	2	3	...
300....	{5635.07	....	...	...	0	...	...
300....	{5635.43	5635.41*	*C*	000	0N	...	...
300....	5636.01	5636.04	*Fe*	1	1	1	...
350....	5637.46	5637.48	*Fe-Ni*	(²) 2	2d	2-3	–1
350....	5638.49	5638.49	*Fe*	3	3	3	...
250....	5639.03	5638.98	*Ni*	00	0	1	...
300....	5639.72	....	...	...	0N	...	...
300....	5640.48	5640.54	*Er*	0	1	3	...
400....	5641.14	5641.21	*Ti-Sc*	1	2	–3	1-1
350....	5641.66	5641.67	*Fe*	2	2	2	...
250....	5643.03	5642.98	*Fe-Ti*	00	0d	...	...
250....	5643.78	....	...	...	0	...	...
300....	5644.31	5644.37	*Ti*	0	3N	3	10
250....	5645.87	5645.83	*Si?*	1	0	...	...
250....	5646.90	5646.90	–	00	0	...	...
250....	5647.45	5647.46	*Co*	00	0	10	...
250....	5648.86	5648.80	*Ti*	00	1	2	3
350....	5649.66	5649.61	*Cr*	00N	1	2	1
350....	5650.08	5650.10	*Fe*	(²) 2	1	2	...
250....	5650.72	....	...	...	1d	...	...
250....	5651.67	5651.69	*Fe-V*	0	0N	–1	–2
250....	5652.58	5652.54	*Fe*	1	0	1	...
350....	5655.62	5655.61	*Fe*	(²) 3	4d	4	...
600....	5658.06	5658.10	*Sc*	2	5	4	2
500....	{5658.50	{5658.56	*Sc*	0	3	2	1
500....	{5658.88	{5658.96	*Fe-Cr*	(³) 6	2	15-1	1–
300....	5660.92	5660.91	–	(³) 1	1N	...	...
300....	5662.38	5662.37	*Ti*	0	0	3	8
400....	{5662.72	5662.74	*Fe*	4	2	10	1
400....	{5663.15	5663.16	*Y-Ti-Fe*	1	3N	10-1-1	15-2-
350....	5664.09	....	...	...	1	...	...
250....	5666.17	....	...	...	0	...	...
350....	5667.42	5667.37	*Sc*	0	2	2	1
300....	5667.70	5667.74	*Fe*	2	1	2	...
400....	5669.23	5669.26	*Sc*	1	3	3	1
250....	5670.04	5670.06	*Ni, Ce*	(²) 1	0d	2, 4	1, 1
350....	5670.99	5671.07	*V*	0	0	10	10
300....	5672.13	5672.05	*Sc*	0	1N	8	1
350....	5675.64	5675.65	*Ti*	2N	1N	3	4
250....	5676.68	....	...	...	0	...	...
350....	5679.25	5679.25	*Fe*	3	3	3	...

* Head of second carbon band.

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths: Chromosphere	Wave-Lengths: Rowland	Substance	Intensities: Rowland	Intensities: Chromosphere	Intensities: Arc	Intensities: Spark
km							
300....	5682.63	5682.43	*Ni*	2	1d	8	1
		5682.87	*Na*	5		10	...
350....	5684.44	5684.42	*Sc*	1	3N	3	1
300....	5684.70	5684.71	*Si*	3	0	...	...
250....	5685.67	5685.66	–	00d	0	...	...
300....	5686.74	5686.76	*Fe*	3	2	5	...
350....	5688.45	5688.44	*Na*	6	1N	15	...
300....	5689.59	....	...	...	0d	...	...
300....	5690.72	5690.65	*Si*	3	0	...	...
250....	5691.62	5691.71	*Fe*	2	0	2	...
350....	5693.91	5693.86	*Fe*	3	2	2	...
350....	5695.11	5695.12	*Ni-Cr*	(²) 2	3d	10-3	1-1
350....	5698.55	5698.56	*Cr*	1	3	4	2
350....	5698.80	5698.75	*V*	1	1	10	15
300....	5700.45	5700.45	*Sc-Ni-Cu*	(³) 0	0	5-2-30	1-1-8
400....	5701.34	5701.32	*Si*	1N	0	...	...
500....	5701.70	5701.77	*Fe*	4	2	4	...
400....	5703.78	5703.80	*V*	1	2N	10	10
250....	5705.62	5705.69	*Fe*	1	0	2	...
350....	5706.20	5706.22	*Fe*	3	2	4	...
350....	5707.20	5707.24	*V-Fe*	(²) 1	1	8-1	10–
400....	5708.46	5708.32	*Fe*	1	1d	1	...
		5708.62	*Si*	3N		1	...
400....	5709.64	5709.69	*Fe, Ni*	(²) 10	3	10, 10	1, 2
400....	5711.15	....	...	...	1	...	...
400....	5712.10	5712.10	*Ni-Fe-Ti*	3	3	5-1-1	1–2
400....	5715.33	5715.31	*Ni-Fe-Ti*	5	2	10-2-2	1–2
400....	5718.08	5718.06	*Fe*	4	2	3	...
300....	5719.80	5719.80	–	1	0	...	...
350....	5720.66	5720.67	*Ti*	0	0	1	1
350....	5727.27	5727.27	*V-Ti*	2N	2	10-1	10–
300....	5731.92	5731.98	*Fe*	4	1	3	...
250....	5732.54	5732.52	–	0	0	...	...
250....	5747.96	5747.89	–	1	0	...	...
250....	5748.34	5748.38	*Fe, Ni*	(²) 4	1d	1, 3	...
250....	5752.20	5752.25	*Fe*	4	1	2	...
400....	5753.35	5753.34	*Fe*	5	2	5	1
400....	5754.85	5754.88	*Ni*	5	2	8	1
300....	5760.88	5760.89	*Ni-Fe*	(²) 3	1d	8–	1–
300....	5763.09	5763.12	*Fe-*	(³) 7	1	10–	1–
300....	5774.23	5774.25	*Ti*	0	0	3	3
250....	5778.63	5778.68	*Fe*	1	0	...	...
350....	5780.86	5780.82	*Fe*	2	1	1	...
400....	5782.37	5782.35	*Fe, Cu*	(²) 6	2	5, 50	1, 10
300....	5784.11	5784.08	*Cr*	3	0	8	1
250....	5784.88	5784.88	*Fe*	1	0	...	...
350....	5785.28	5785.19	*Cr*	2	1	6	3
		5785.50	*Fe*	3		...	...
300....	5786.11	5786.04	*Cr-Ti*	(²) 2	0	5-3	1-3
350....	5791.27	5791.24	*Cr-Fe*	3	1	15-1	3–
350....	5798.05	5798.08	–	3	0	...	...

TABLE I—*Continued*

Height of Chromosphere	Wave-Lengths		Substance	Intensities			
	Chromosphere	Rowland		Rowland	Chromosphere	Arc	Spark
km							
300....	5804.54	5804.48	*Ti*	0	0	3	3
300....	5805.48	5805.44	*Ni*	4	0	15	...
300....	5806.91	5806.95	*Fe*	5	0	2	...
250....	5809.48	5809.44	*Fe*	4	0	1	...
300....	5812.14	5812.14	*Fe*	0	0	...	...
300....	5814.21	5814.23	–	00	0	...	...
300....	5816.57	5816.60	*Fe*	5	0	5	...
250....	5828.07	5828.10	–	0	0	...	...
300....	5852.45	5852.44	*Fe*	3	0	...	...
400....	5853.90	5853.90	*Ba*	5	4	200	100
400....	5857.72	5857.67	*Ca*	8	3	10	4
300....	5859.75	5859.81	*Fe*	5	1	4	1
350....	5862.64	5862.64	*Fe*	6	2	10	1
250....	5864.50	5864.46	–	0	0	...	...
250....	5866.38	....	...	...	0	...	...
300....	5867.87	....	...	...	0	...	...
7500....	5876.42	(5875.87)	*He*	...	40	...	...
300....	5879.94	5879.94	*Zr*	1	0	4	1
1000....	5890.4	5890.19	*Na*	30	10	1000	10
400....	5892.7	5892.6	–	3	1	...	...
400....	5893.3	5893.1	*Ni*	4	1	10	1
1000....	5896.1	5896.16	*Na*	20	10	1000	8
300....	5899.5	5899.5	*Ti*	1	0	2	10
300....	5906.0	5905.9	*Fe*	4	0	3	...
400....	5914.2	5914.3	*Fe*	4	2	10	1
400....	5916.4	5916.5	*Fe*	3	1	1	...
300....	5922.0	....	...	...	0	...	...
250....	5928.0	5928.0	*Fe*	2	0	1	...
400....	5929.9	5930.3	*Fe*	(²) 8	2d?	10	1
400....	5935.1	5934.9	*Fe*	5	2	3	1
400....	5948.4	5948.8	*Si*	6	1	...	...
500....	5953.2	5953.0	*Ti-Fe*	(²) 5	2	3-2	10-1
400....	5956.7	5956.9	*Fe*	4	1	1	...
400....	5966.1	5966.1	*Ti*	2	1	2	10
300....	5975.5	5975.6	*Fe*	3	0	2	...
300....	5977.0	5977.0	*Fe*	4	0	3	...
300....	5984.0	5983.9	*Fe*	5	1	4	1
400....	5984.9	5985.0	*Fe*	6	1	8	1
400....	5987.2	5987.3	*Fe*	5	1	4	...
300....	5991.5	5991.6	–	2	1	...	...
300....	5997.6	(5997.4)	*Ba*	...	0	50	10
400....	6002.9	6003.2	*Fe*	6	1	4	1
400....	6008.1	6008.2	*Fe*	4	1	2	...
400....	6016.9	6016.9	*Mn*	6	1	30	1
400....	6020.3	6020.3	*Fe*–	(²) 6	2	10–	1–
400....	6022.0	6022.0	*Mn*	6	1	30	1
400....	6024.1	6024.3	*Fe*	7	2	15	3
300....	6027.2	6027.3	*Fe*	4	1	3	...
300....	6042.3	6042.3	*Fe*	3	1	3	...
400....	6056.3	6056.2	*Fe*	5	1	5	1

TABLE I—*Continued*

Height of Chromo-sphere	Wave-Lengths		Substance	Intensities			
	Chromo-sphere	Rowland		Rowland	Chromo-sphere	Arc	Spark
km							
400....	6065.7	6065.7	*Fe*	7	2	10	1
400....	6079.1	6078.9	*Fe*	(²) 7	2	5	...
300....	6102.1	6102.4	*Fe*	6	1	5	1
300....	6102.8	6102.9	*Ca*	9	1	3	...
300....	6103.6	6103.5	*Fe*-	(²) 5	1	3	...
300....	6116.4	6116.4	*Ni-Fe*	(²) 5	0	20-1	1-
400....	6137.0	6136.9	*Fe*	(²) 11	1	10	3
400....	6138.0	6137.9	*Fe*	7	1	...	...
500....	6141.9	6141.9	*Ba-Fe*	7	5	1000-3	200-
300....	6155.4	6155.4	-	7	0	...	..
300....	6163.8	6163.7	*Ni-Fe*	3	0	10-1	1-
300....	6191.6	6191.6	*Ni, Fe*	(²) 15	1	8, 10	1, 3

Altogether 2841 lines are here tabulated in the spectrum of the chromosphere. In addition to the above, many faint lines were measured. In some parts of the spectrum on account of the great density of the continuous spectrum, it was excessively difficult to set on these faint lines. No lines, even faint ones, were included in the 2841 enumerated, unless they were measured in two or more separate measurements. Even many lines measured at least twice were not included, for it seemed unwise to increase the length of the tables by including lines which could not be more or less positively identified by comparison with Rowland. In attempting to measure the faintest lines, it was at once realized that it was easy to draw on one's imagination and fancy that a line existed where there was possibly nothing more than an accidental lining-up of silver grains in spite of the fact that a rather low power of about 5 was employed in the measurement. It is thought by the writer that very few lines are included in the 2841 which have not a real existence in the chromospheric spectrum. In Table III will be seen that only 126 lines are included which have not been identified with lines in Rowland.

In order to give an idea of the intensities of the lines of the chromosphere, Table II is added which gives the individual intensities of the lines for each hundred angstroms of wave-length.

TABLE II

FLASH SPECTRUM INTENSITIES

Arranged according to Intensities

Region	0	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	35	40	45	50	55	60	70	80	100	Total
3318–3400	22	11	13	7	3	5	1		3		1	1														67
3400–3500	46	22	14	8	7	3		1	1																	102
3500–3600	49	35	15	10	5	5	1		1																	121
3600–3700	32	36	16	6	8	4	5		4		2	2	1	1				1								118
3700–3800	24	33	23	4	8	1			4		4		1	1	2	1	1	2	2	2						113
3800–3900	10	64	41	16	5	4			3		3		2	2		1		1			1	1				148
3900–4000	19	43	28	8	7	2	5		4		2		1	2								1		1	1	124
4000–4100	48	43	37	13	6	2	3		2	1	1	2	2	1				1								162
4100–4200	28	33	40	23	3	10	2		3		3	1											1			147
4200–4300	21	51	34	21	5	3	2		2		1		4	2	1	1		1								149
4300–4400	35	27	24	10	6	6	2		1		3	4	6		1									1		126
4400–4500	42	31	33	18	11	3	6	1	2		3	1	2	2				1								156
4500–4600	35	42	22	13	4	2	2		3			1	3	4												131
4600–4700	44	34	26	14	4	1						1														124
4700–4800	36	38	21	10	4																					109
4800–4900	22	37	12	5		4	2																		1	83
4900–5000	43	32	12	3	1				1		1	1		1												95
5000–5100	53	29	21	4		1							1													109
5100–5200	50	36	20	9	3							1	1	1	1											122
5200–5300	45	25	16	4	1	2	2		1			1														97
5300–5400	36	17	17	8	2	2	2		3			1														88
5400–5500	32	28	11	6	3	2	1	1	4			1														89
5500–5600	34	18	14	4	7	4	2	1	1		1															86
5600–5700	29	24	11	10	1	2			1																	78
5700–5800	13	11	9	2																						35
5800–5900	14	3	1	1	1						2							1								23
5900–6191	9	21	8			1																				39
Totals	871	824	539	231	105	69	38	4	44	1	27	18	24	17	5	3	1	8	2	2	1	2	1	2	2	2841

PLATE XVII

SPECTRUM OF CHROMOSPHERE—REGION FROM H_β TO b GROUP

Negative enlarged sixfold

In Table III is given a summary of all lines arranged according to the element producing them. In making this table, it was a problem to know the best way to treat lines which are due to more than one substance. Although slightly erroneous values may be thereby obtained, it was thought advisable to assign each line to only one element. In all cases, therefore, the element printed first in the column "Substance" in Table I was practically regarded as the sole cause of a line under consideration. A result of this procedure is seen with the element hydrogen. Thirty-five lines of hydrogen appear in Table I, the line at 4686.00, and 34 of the well known series. But 30 appear in Table III, for the reason that some of the fainter lines of the series have a combined source, and have been assigned to other sources than *H* as *Fe* or *Ti*.

In the first column under "Element," — means that the lines were identified with lines in Rowland's tables, but no source could be assigned to the lines. "Unidentified" means that the lines could not be identified with a line in Rowland. It will be seen that there are but 126 of these, or in other words it has been found possible to assign sources to all but 4 per cent of the lines measured in the chromosphere.

An interesting comparison is made by tabulating the totals for the various elements given in the last column in Table III according to their atomic weights. In Table IV is given the periodic table of atomic weights with the international values adopted in 1910. This table is taken from the values in *Encyclopaedia Britannica*, 11th edition, Vol. 9, p. 258, under "Element." In the table, under each element is given, first the atomic weight, and second (*in italics*) the total number of lines from each element found in the chromospheric spectrum. A heavy line is drawn to include all the elements found. In addition to the elements within this heavy line there is also hydrogen, represented by 30 lines. *Ag* (atomic weight, 108) and *Cd* (atomic weight, 112) seem to be represented in the chromosphere by weak lines in combination with stronger lines of other elements, and possibly also *Nb* (atomic weight, 93) and *Mo* (atomic weight, 96).

There are thus found in the chromosphere nearly all the elements which are found in the ordinary solar spectrum. In the

TABLE III

Flash Spectrum Intensities

Arranged according to Elements

Element	3318 to 3400	3400 to 3500	3500 to 3600	3600 to 3700	3700 to 3800	3800 to 3900	3900 to 4000	4000 to 4100	4100 to 4200	4200 to 4300	4300 to 4400	4400 to 4500	4500 to 4600	4600 to 4700	4700 to 4800	4800 to 4900	4900 to 5000	5000 to 5100	5100 to 5200	5200 to 5300	5300 to 5400	5400 to 5500	5500 to 5600	5600 to 5700	5700 to 5800	5800 to 5900	5900 to 6191	Total
Fe	6	21	37	36	35	37	29	32	36	40	18	22	22	22	20	18	34	31	33	33	33	36	28	23	15	7	25	729
Ti	22	12	11	12	11	4	13	18	12	15	23	28	21	19	12	11	13	25	11	9	8	7	5	5	2	2	2	333
Cr	14	10	3	7	3	1	6	3	6	15	11	5	13	28	9	9	3	2	7	13	10	4	2	3	4	...	...	191
V	2	3	12	2	7	6	12	21	13	13	10	20	10	5	6	5	2	2	3	4	2	2	2	3	3	...	...	170
C	...	...	4	1	22	65	...	...	12	1	...	...	...	3	3	...	3	13	31	...	...	...	...	1	...	1	...	160
Ni	4	8	11	5	3	3	2	2	1	...	2	5	4	4	11	10	14	15	10	4	1	6	6	6	4	2	3	146
Zr	8	17	8	13	6	6	7	9	7	16	7	8	4	4	3	1	...	...	...	1	1	...	...	...	...	1	...	127
Co	3	10	15	3	4	7	9	9	7	...	...	2	6	...	3	3	1	...	...	5	9	3	2	1	...	...	...	102
Mn	...	6	6	...	1	4	2	14	2	7	...	8	2	...	8	2	...	1	1	1	3	4	4	...	...	...	2	78
Ce	...	1	1	...	...	...	7	9	15	6	5	10	5	1	...	...	...	1	...	1	2	1	...	2	...	...	...	67
Sc	4	...	7	6	...	...	3	7	1	1	5	2	...	1	3	...	...	2	...	1	4	...	1	6	1	...	...	55
Nd	...	...	...	...	1	...	5	6	6	6	5	4	3	1	3	3	1	1	1	2	1	3	1	1	...	...	...	54
Y	1	1	1	6	4	1	3	2	2	2	4	3	...	1	1	2	2	2	2	...	...	3	4	1	...	...	...	48
La	2	...	...	...	3	1	5	4	4	8	2	2	3	1	2	1	2	...	2	1	...	...	...	...	...	...	...	43
Ca	...	...	...	1	1	...	3	1	...	3	3	4	4	...	...	...	...	1	...	3	1	...	6	2	...	1	1	35
H	...	...	...	16	7	2	1	...	1	...	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	30
Gd	...	1	2	...	...	1	1	8	1	1	4	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	22
Sa	...	...	...	1	...	...	...	...	...	2	...	6	6	3	1	...	...	...	...	...	...	...	...	...	...	...	...	19
Er	...	2	...	3	1	2	...	1	3	1	1	...	...	...	...	...	1	...	...	...	...	...	...	2	...	...	...	17
He	...	...	...	1	1	1	1	2	3	...	1	2	...	...	1	...	1	1	...	...	...	...	...	...	...	...	...	15
Sr	...	1	...	...	...	...	...	1	...	1	1	1	...	1	1	...	...	...	...	2	...	1	2	...	...	...	...	12
Ba	...	...	...	...	...	1	1	...	2	...	...	1	2	...	...	...	1	...	...	...	...	...	...	...	...	1	2	11
Mg	...	...	...	...	...	3	...	...	...	...	...	1	1	...	1	...	...	...	3	...	...	...	1	...	...	...	...	10
Si	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	1	...	1	7
Eu	...	...	...	...	...	...	1	...	1	...	1	...	...	1	...	...	1	...	...	...	...	...	1	...	...	...	...	6
Zn	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1	...	...	...	...	...	...	...	...	...	...	4
Al	...	...	1	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Na	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	2	...	3
Dy	...	...	...	...	...	...	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Cu	...	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Pr	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Nh	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
—	1	3	...	1	3	3	5	10	9	9	16	11	12	20	15	6	10	7	10	6	10	14	12	8	4	4	2	211
Unidentified	...	6	2	4	...	...	4	2	1	1	5	7	12	7	5	10	5	5	8	11	3	5	9	10	1	2	1	126
Totals	67	102	121	118	113	148	124	162	147	149	126	156	131	124	109	83	95	109	122	97	88	89	86	78	35	23	39	2841

TABLE IV

Periodic Table of Atomic Weights

In italic figures are given the total number of lines for each element found in the chromosphere.

He 4 *15*	*Li* 7 ..	*Be* 9 ..	*B* 11 ..	*C* 12 *160*											*N* 14 ..	*O* 16 ..	*Fl* 19 ..
Ne 20 ..	*Na* 23 *3*	*Mg* 24 *10*	*Al* 27 *3*	*Si* 28 *7*											*P* 31 ..	*S* 32 ..	*Cl* 35 ..
A 40 ..	*K* 39 ..	*Ca* 40 *35*	*Sc* 44 *55*	*Ti* 48 *333*	*V* 51 *170*	*Cr* 52 *191*	*Mn* 55 *78*	*Fe* 56 *729*	*Ni* 59 *146*	*Co* 59 *102*	*Cu* 64 *2*	*Zn* 65 *4*	*Ga* 70 ..	*Ge* 72 ..	*As* 75 ..	*Se* 79 ..	*Br* 80 ..
Kr 83 ..	*Rb* 85 ..	*Sr* 87 *12*	*Y* 89 *48*	*Zr* 91 *127*	*Nb* 94 ..	*Mo* 96 ..		*Ru* 102 ..	*Rh* 103 ..	*Pd* 106 ..	*Ag* 108 ..	*Cd* 112 ..	*In* 115 ..	*Sn* 119 ..	*Sb* 120 ..	*Te* 127 ..	*I* 127 ..
Xe 131 ..	*Cs* 133 ..	*Ba* 137 *11*	*La* 139 *43*	*Ce* 140 *67*	*Pr* 141 *1*	*Nd* 144 *54*	*Sa* 150 *19*	*Eu* 152 *6*	*Gd* 157 *22*								
			Tb 159 ..	*Dy* 162 *3*	*Nh* ? *1*	*Er* 167 *17*	*Tm* 168 ..	*Ny* 172 ..	*Lu* 174 ..								
					Ta 181 ..	*W* 184 ..		*Os* 191 ..	*Ir* 193 ..	*Pt* 195 ..	*Au* 197 ..	*Hg* 200 ..	*Tl* 204 ..	*Pb* 207 ..	*Bi* 208 ..		
		Ra 226 ..		*Th* 232 ..		*U* 238 ..											

chromosphere in addition is found helium, and also a few of the rare earths like *Dy* and *Nh* which have been isolated since Rowland's identifications were made.

According to the comparisons of Rowland (Young, *General Astronomy*, p. 215), the elements in the solar spectrum arranged in the order of the total number of lines identified are as follows for the first twenty-five elements: $\overset{1}{Fe}, \overset{2}{Ni}, \overset{3}{Ti}, \overset{4}{Mn}, \overset{5}{Cr}, \overset{6}{Co}, \overset{7}{C}, \overset{8}{V}, \overset{9}{Zr}, \overset{10}{Ce}, \overset{11}{Ca}, \overset{12}{Sc}, \overset{13}{Nd}, \overset{14}{La}, \overset{15}{Y}, \overset{16}{Nb}, \overset{17}{Mo}, \overset{18}{Pd}, \overset{19}{Mg}, \overset{20}{Na}, \overset{21}{Si}, \overset{22}{H}, \overset{23}{Sr}, \overset{24}{Ba}, \overset{25}{Al}$. In the chromosphere, according to Table III, the order is: $\overset{1}{Fe}, \overset{2}{Ti}, \overset{3}{Cr}, \overset{4}{V}, \overset{5}{C}, \overset{6}{Ni}, \overset{7}{Zr}, \overset{8}{Co}, \overset{9}{Mn}, \overset{10}{Ce}, \overset{11}{Sc}, \overset{12}{Nd}, \overset{13}{Y}, \overset{14}{La}, \overset{15}{Ca}, \overset{16}{H}, \overset{17}{Gd}, \overset{18}{Sa}, \overset{19}{Er}, \overset{20}{He}, \overset{21}{Sr}, \overset{22}{Ba}, \overset{23}{Mg}, \overset{24}{Si}, \overset{25}{Eu}$.

By comparing the relative orders of the elements in the two lists just given for sun and chromosphere, and also having regard to the general intensities of the lines in the various elements, we find that the elements can be divided into three groups as follows:

GROUP I.—*Lines strong in the sun, strong in the chromosphere: Ca, Mg, Al.*

Although there are relatively more lines in the solar spectrum for each element than in the chromosphere, these are grouped together on account of the great strength of H and K, the *b* group, etc.

GROUP II.—*Lines relatively stronger in the chromospheric than in the solar spectrum:*

H, He, Ti, Cr, C, V, Zr, Sc, La, Y, Sr, Ba, Nd.

GROUP III.—*Lines relatively stronger in the solar than in the chromospheric spectrum:*

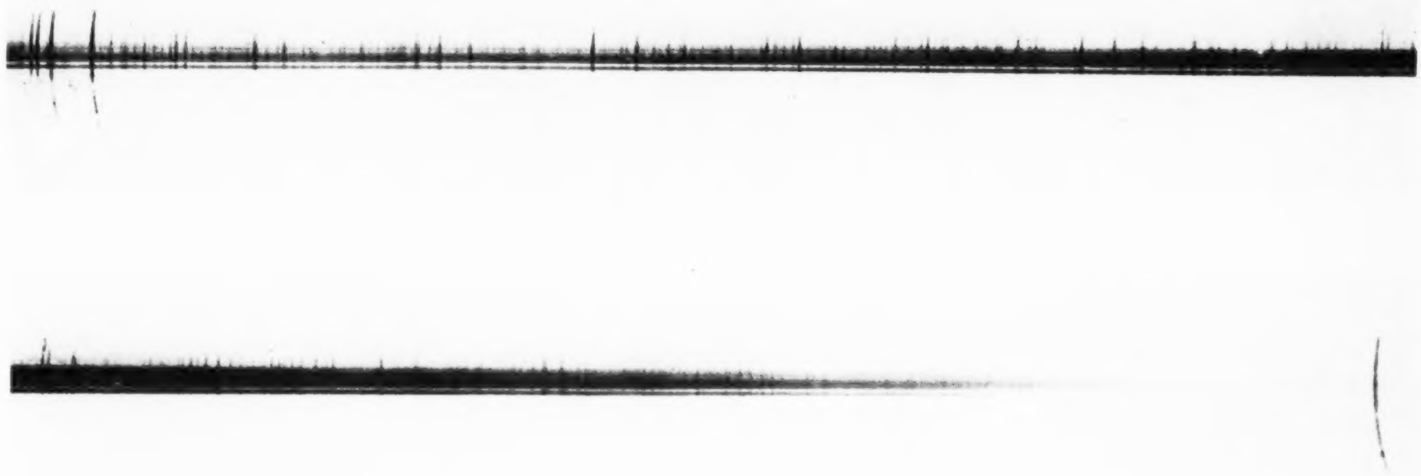
Fe, Ni, Co, Mn, Na, Nb, Mo, Pd.

Although *Fe* heads the list in sun and chromosphere, it is put in this group along with *Ni* and *Co*.

This is practically the same grouping as was obtained in the discussion of the 1901 eclipse.[1] From the 1901 eclipse, the grouping came as a result of comparing *intensities* only. The grouping as above, coming from comparing *numbers* only must give the same results as a comparison of intensities, for the reason that if all the

[1] *Publications of the Naval Observatory*, Second Series, Vol. **4**, App. 1, p. 290; *Astrophysical Journal*, **15**, 97, 1902.

PLATE XVIII



SPECTRUM OF CHROMOSPHERE—REGION FROM *b* GROUP TO D_3

Negatives enlarged sixfold

lines of a given element are relatively strengthened, more than the average number of the fainter lines necessarily become visible in the chromosphere, and, consequently, more lines are measured.

It is thus seen that *Fe* and *Ti*, for instance, belong to different groups. This means that on the average a *Ti*-line of any given intensity in the sun, say 5, would have a stronger line in the chromosphere corresponding to it than a *Fe*-line of the same intensity.

ENHANCED LINES

As mentioned above, the chromospheric and solar spectra agree exactly as to wave-lengths, but differ very greatly in their intensities. The differences in intensity are accentuated in the case of the "enhanced" lines, which are those more intense in the spark than they are in the arc. The importance of enhanced lines in eclipse spectra was first recognized by Sir Norman Lockyer. The present measures confirm this important rôle played by the enhanced lines, and, consequently, there is included in the spark intensities Lockyer's list of enhanced lines, denoted by prefixing the letter "L." By referring to the intensities in arc and spark, one can see for himself which lines, in addition to the L-lines, are enhanced.

Reference to Table I will show that the enhanced lines in the chromosphere are not only stronger but they extend to higher levels than do the unenhanced lines. These greater heights bring as a natural result several important consequences: (1) changes in thermal conditions; (2) changes in electrical conditions; (3) changes in pressure; (4) a more ready mixing with the gases of the upper chromosphere, such as hydrogen. A brief glance at the results of the above four changes of condition may not be without interest.

1. Lockyer's explanation of the brilliancy of the enhanced lines has always been one mainly of temperature. According to him, the spark is hotter than the arc, and at the higher temperature of the spark, the elements are dissociated. Applied to the chromosphere, this has always borne a curious consequence. To account for the increased strength of the enhanced lines in the chromosphere on Lockyer's supposition that they are the result of tempera-

ture only, we must assume that, as we ascend to higher levels above the photosphere, we reach greater and greater temperatures, a conclusion which seems to be a rather contradictory one. The majority of spectroscopists disagree with Lockyer. As far back as 1884, Liveing and Dewar[1] stated that "there is no good reason for assuming that the energy which takes the form of radiation in the electric discharge through a gas must first take the form of motion of translation of the particles, on which temperature depends." According to Hartmann,[2] in comparing arc and spark spectra, "spark lines do not correspond to a thermal radiation but rather to electro-luminescence."

The question of temperature in its relation to spectrum lines is summed up by Kayser[3] as follows: "We can prove no connection between the spectrum and the temperature, and all conclusions concerning the appearance of certain lines and bands which are based on temperature conditions are decidedly unsound." For the present purpose, it is not necessary to enter the controversy as to whether the spark is hotter or colder than the arc. It seems certain that Lockyer's conclusion that the higher chromosphere is at a higher temperature than the lower chromosphere is erroneous, but it is equally certain that the vapors of the higher chromosphere are nevertheless at relatively high temperatures. To the present writer it seems that thermal changes play a very unimportant rôle in the explanation of the causes of the enhanced lines.

2. As is well known, variations in electrical conditions change enormously the character of the lines of the spectrum. Unfortunately, we are not familiar with the nature of the electro-luminescence at the surface of the sun, nor are we aware of how the enhanced lines in particular are altered by changes in these conditions, and hence we shall be forced to leave this for the present without further investigation.

3. Much excellent work has been done on the subject of the pressures at the sun's surface. The most recent determination of the pressure in the reversing layer has been made by Fabry and

[1] *Phil. Mag.* (5), **18**, 161, 1884.

[2] *Astrophysical Journal*, **17**, 270, 1903.

[3] *Handbuch der Spectroscopie*, Bd. II, p. 181.

Buisson,[1] who give a value of 5 atmospheres. Perot's value is substantially the same. In the chromosphere at the average heights of the enhanced lines, the pressure would be very much less. According to the researches of Gale and Adams,[2] the titanium arc at reduced pressures shows a marked increase of relative intensity for the enhanced lines. Barnes found a similar result for *Al*, *Mg*, and *Cu*.[3] Moreover, Gale and Adams found that the enhanced lines show materially larger displacements both at the sun's limb and under pressure than do the other lines. They also showed that at moderate pressures the enhanced lines remain bright while a majority of the other lines are reversed. These various considerations prove that pressure is a very potent factor in altering the character of spectrum lines and that enhanced lines in particular are very sensitive to changes in pressure. Conclusions seem obvious. Enhanced lines, for some reason (as seen from Table I), in the chromosphere ascend to much greater heights on the average than do lines of the same element not enhanced. At these higher elevations, pressure is much reduced. This reduction in pressure causes a brightening of these lines. It was pointed out above that since the moon gradually covers up the chromosphere, the strongest lines, in general, are those which correspond to vapors which extend to the greatest heights. But high elevations cause a reduction in pressure which entails a strengthening of the enhanced lines. The prime cause, therefore, of the strengthening of the enhanced lines is the heights to which the vapors ascend. These great heights bring an additional consequence as enumerated in (4), viz., the vapors belonging to the enhanced lines are more readily mixed with the higher gases of the chromosphere such as helium and hydrogen. It is a well known fact[4] that an atmosphere of hydrogen has the effect of strengthening the enhanced lines. Hence, we find here another cause for the greater strength of the enhanced lines.

The final conclusion therefore seems to be that the vapors forming the enhanced lines ascend to relatively high altitudes from

[1] *Astrophysical Journal*, **31**, 97, 1910.

[2] *Ibid.*, **35**, 10, 1912.

[3] *Ibid.*, **34**, 159, 1911.

[4] Crew, *Ibid.*, **12**, 167, 1900.

which results a decrease in pressure and a mixing with hydrogen, and that on account of height, reduced pressure, and the presence of hydrogen, the enhanced lines become relatively strong.

ELEMENTS IDENTIFIED

As may be seen from Tables III and IV, 32 elements are found in the chromosphere. As before stated, these two tables give only those identifications which may be regarded as the principal cause of each chromospheric line. In addition to the lines in Tables III and IV, there are many in each element not enumerated there because they were of minor importance in the blended lines, but which, nevertheless, appear in Table I and correspond to lines of the chromosphere. A comparison of Table I with Vol. 1 of Exner and Haschek's tables where is given a codex of the strongest lines of the different spectra shows that, practically without exception, the chief lines of each of the 32 elements are found in the chromosphere.

From the tables, one can readily see the elements identified. A few need special mention.

Hydrogen.—Including H_a, which is on the plane grating spectrum, but which is not enumerated in Table I, the wave-lengths of 35 lines of the hydrogen series are given. As above stated, on account of the great heights to which hydrogen ascends, it is impossible to determine wave-lengths from slitless spectra with as great an accuracy as if a slit had been used. Nevertheless, the measured wave-lengths agree closely with Balmer's well known law where the limit of the series is at λ 3646.125. At the thirty-fifth line, the hydrogen lines crowd closely together in the spectrum, being separated by approximately 0.5 angstrom. A few additional hydrogen lines were measured, but they are not tabulated. The values of wave-lengths agree closely with those determined by Dyson from the eclipses of 1900, 1901, and 1905.[1]

A line near λ 4686 has been observed in many eclipse spectra. Fowler,[2] by laboratory experiments, has found this to belong to

[1] *Phil. Trans. Roy. Soc.*, **206** A, 438, 1906.

[2] *Monthly Notices, R.A.S.*, **73**, 62, 1912.

the principal series of hydrogen and measured its wave-length as 4685.98 on Rowland's scale. This line is well seen in the present spectra as a diffuse line extending to 2000 km above the photosphere. From these slitless spectra, accurate measures of its wave-length are rather difficult. The value of the wave-length from the present spectra is 4686.00.

If any lines of hydrogen are present other than those belonging to the well known series and this one line of the principal series, the lines must be weak in intensity.

The rare earths.—Of the 2841 lines tabulated, no less than 336, or about one-eighth of the total, belong to the rare earths. Chemists have been able to divide and subdivide these, so that at the present (1913), the separation of these elements is given in Table V.[1] The elements are given in *italics*.

Reference to Exner and Haschek, Bd. I, p. 35, will show that these elements are very rich in lines both in the arc and spark. Practically, all the rare earths are represented in the chromosphere by their strongest lines.

Rare gases of atmospheric air.—In 1903, the writer announced[2] the presence of neon and argon in the flash spectrum of the 1901 eclipse. According to Evershed,[3] these conclusions were based on insufficient evidence, since the wave-lengths of the neon lines were not known at that time with sufficient accuracy to give a decisive result.

The writer has not thought it necessary to here tabulate wave-length comparisons. He finds that in the region λ 3300 to λ 6200, there are twenty-five lines of neon having an intensity of 4 or greater. Of these lines, there are only four falling sufficiently close to chromospheric lines to be considered coincidences, and these lines are not the strongest lines of neon. In the argon spectrum in the same region, there are sixty-one lines with intensities greater than 4 in the red and blue spectra as given by Kayser, and but fourteen cases which might be called coincidences, the lines again not being

[1] See *Encyclopaedia Britannica*, 11th ed., Vol. **22**, p. 909, under "Rare Earths."

[2] *Astrophysical Journal*, **17**, 224, 1903.

[3] *Kodaikanal Bulletin No. 27*, 1912.

TABLE V

RARE EARTHS

- Ceria
  - *Ceria*
  - Lanthana
    - *Lanthana*
    - Didymia
      - Samaria
        - *Samaria*
        - *Europia*
      - Didymia
        - *Praesodymia*
        - *Neodymia*

- Yttria
  - *Yttria*
  - Erbia (Mosander)
    - Terbia (Delafontaine)
      - *Terbia*
      - *Gadolinia*
  - Terbia (Mosander)
    - Erbia (Berlin)
      - Ytterbia
        - Ytterbia
          - *Neoytterbia*
          - *Lutecia*
        - *Scandia*
      - Thulia
      - Soret's X
        - Holmia
          - Holmia
            - *Neoholmia*
          - *Dysprosia*
      - Erbia

the strongest. In both the neon and argon coincidences, the lines are sufficiently identified with lines in Rowland.

Although Mr. Evershed and the writer do not in all cases agree on the identification of the lines in the violet, they arrive at the same conclusion, viz., that there is no evidence to show that neon, argon, krypton, or xenon are present either in the chromosphere or in the ordinary solar spectrum.

Radioactive substances.—The writer's opinion regarding radium, radium emanation, and uranium in the sun has been published in *Astronomische Nachrichten*, 4600, and *Popular Astronomy*, **21**, 1, 1913. His conclusions, which do not agree with those of Dyson,[1] are as follows (*Popular Astronomy*): "From theoretical considerations we are positively convinced that there must be radium in the sun. But to prove this is another problem! With the spectra we already have, we can prove nothing more than accidental coincidences."

THE FLASH SPECTRUM WITHOUT AN ECLIPSE

Comparisons of the present spectra with those obtained by Hale and Adams[2] will not be without interest. Their photographs were made with the 60-foot tower telescope and 30-foot spectrograph of Mount Wilson. The solar image given by this telescope is 6.7 inches (17 cm) and the dispersion is such that for photographs in the second order 1 mm = 0.9 angstrom.

Although their dispersion was about twelve times that used by the writer, in the region from λ 4492 to λ 4584 they give altogether 37 lines. In the same region in Table I will be found 118 lines, or over three times as many. In the green region, where their visual object-glass performed to much better advantage, they have photographed between λ 5111 and λ 5198. The writer made a close comparison (which those interested may readily do) between their wave-lengths and his values in Table I, and reached the following conclusions: (1) In spite of the twelvefold greater dispersion, the wave-lengths have about an equal accuracy. (2) Practically every line in Hale and Adams is found in Table I. (3) From

[1] *Astronomische Nachrichten*, 4589.

[2] *Astrophysical Journal*, **30**, 222, 1909.

Hale and Adams' list, there are some curious omissions. They have no lines between λ 5126.18 and λ 5130.76, omitting the chromospheric line at λ 5129.41, an enhanced *Ti*-line of intensity 3. They have measured no lines between λ 5138.70 and λ 5141.38 leaving out the *Fe-V* line of intensity 4 in the chromosphere at λ 5139.60. Many relatively strong lines in the chromosphere did not appear in their photographs, although very weak lines of the green carbon band were measured. It seems that the difference in the two spectra, with and without an eclipse, is one mainly of elevation, the spectra without an eclipse being taken at a higher elevation. Consequently, eclipse spectra include all the lines taken without an eclipse, and in addition lines of lower level, the latter probably outnumbering the former. Taking the whole spectrum, it may not be unreasonable to say that the 1905 flash spectrum would have twice as many lines with wave-lengths quite as accurate as those obtained with the 60-foot tower telescope. The results from the use of the 150-foot tower telescope at Mount Wilson will be watched with the greatest interest.

GENERAL CONCLUSIONS

As a result of these 1905 eclipse spectra it seems safe to make the following conclusions:

1. The flash spectrum is a reversal of the Fraunhofer spectrum.

2. The flash is not an instantaneous appearance, but the chromospheric lines appear gradually. At the beginning of totality, those of greatest elevation appear first, and at the end of totality remain the last. The "reversing layer" which contains the majority of the low-level lines of the chromosphere is about 600 km in height.

3. Wave-lengths in chromospheric and solar spectrum are practically identical.

4. The chromospheric spectrum differs greatly from the solar spectrum in the intensities of the lines.

5. These differences in intensity find a ready explanation in the heights to which the vapors ascend.

6. Especially prominent in the chromosphere are the enhanced lines which become brighter mainly because at the heights to which

they ascend the vapors are mixed with hydrogen at reduced pressures.

7. The great value of gratings for eclipse work is shown by the present spectra. The normal spectrum permits a ready determination of wave-lengths which are quite as accurate at the red end of the spectrum as they are at the violet end. Of gratings, plane and concave, the latter are to be preferred.

8. Compared with the writer's eclipse measures of 1901, the present spectra are in better focus, and extend farther to both the red and violet ends. The wave-lengths of the present paper were closely compared with those of Evershed[1] for the eclipses of 1898 and 1900, and with those of Dyson[2] obtained at the eclipses of 1900, 1901, and 1905, both of whom used prisms. Their wave-lengths are quite accurate in the violet, but gradually decrease in accuracy toward the red due to the decrease of dispersion inherent in prismatic spectra.

9. The present spectra were obtained at the central line of totality. It might be well to go in 1914, as Evershed went in 1900, near the edge of the shadow-path. This would permit of relatively longer exposures on the regions of lower-level. If spectra were obtained with a dispersion equal to or greater than the present, comparisons would be very interesting. It would be desirable to extend the spectrum farther into the red by the use of plates sensitive to the red.

Leander McCormick Observatory
University of Virginia
August 1913

[1] *Phil. Trans. Roy. Soc.*, **201** A, 457, 1903

[2] *Ibid.*, **206** A, 438, 1906.

DARK REGIONS IN THE SKY SUGGESTING AN OBSCURATION OF LIGHT

By E. E. BARNARD

The so-called "black holes" in the Milky Way are of very great interest. Some of them are so definite that, possibly, they suggest not vacancies, but rather some kind of obscuring body lying in the Milky Way, or between us and it, which cuts out the light from the stars. This explanation seems to become more and more plausible the more we know of these objects. In previous papers I have called attention to this possible obscuring matter, splendid examples of which are connected with the great nebulosities about the stars ρ *Ophiuchi* and ν *Scorpii*. See *Astrophysical Journal*, **31**, 8, 1910, for an article bearing on this subject.

One of the most remarkable of these spots—remarkable because of its smallness and definite form—is in one of the dense star-clouds, in the position:

$$1855.0 \qquad \alpha = 18^h 7^m \qquad \delta = -18^\circ 15'.$$

Photographs taken with portrait lenses show it to be about 15′ in diameter, north and south, with its following side very sharply defined. The preceding side is diffused and sprinkled with small stars. Near the center is a considerable star, with one or two smaller ones near it. To show the location of this object in the sky, a photograph taken by the writer at Mount Wilson, California, on July 31, 1905, with the 10-inch Bruce lens of the Yerkes Observatory, with an exposure of $4^h 30^m$ is given (Plate XIX). Its true form, however, is more clearly shown in the fourfold enlargement (Plate XX, Fig. 2).

Known to me in my early days of comet-seeking, this object has always been of the deepest interest, and it was one of the first subjects that I sought to study with the Willard lens at the Lick Observatory. I have also examined it repeatedly with the great telescopes of the Lick and Yerkes observatories. In these visual

PLATE XIX

North

E. E. Barnard

Scale $\begin{cases} 1 \text{ in.} = 77'.9 \\ 1 \text{ cm} = 30'.7 \end{cases}$

BLACK SPOT IN STAR CLOUD IN SAGITTARIUS

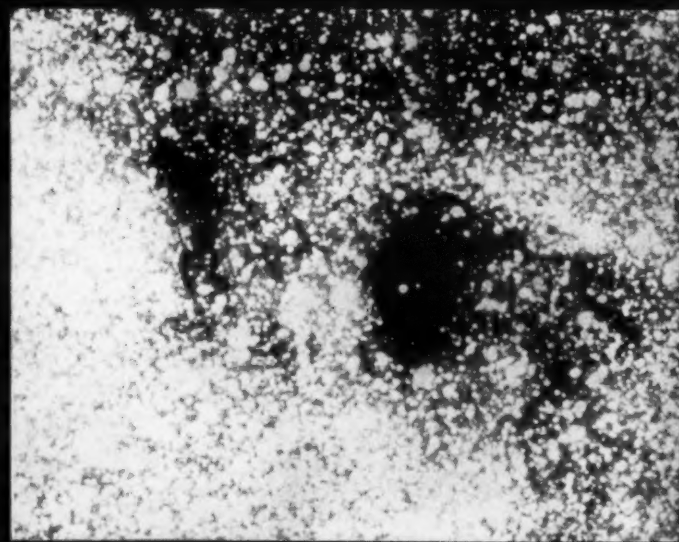
1855.0 $\alpha = 18^h 7^m$ $\delta = -18°15'$

10-inch Bruce telescope 1905 July 31, Exposure $4^h 30^m$

PLATE XX

North

North



E. E. Barnard

FIG. 1 (Negative)

BLACK SPOT IN NEBULOUS STREAM SOUTH FROM ζ ORIONIS

1855.0 $\alpha = 5^h 33^m.6$ $\delta = -2°35'$

Enlarged 4.3 times, Scale $\begin{cases} 1 \text{ in.} = 15'.1 \\ 1 \text{ cm} = 5'.9 \end{cases}$

FIG. 2 (Positive)

BLACK SPOT IN STAR CLOUD IN SAGITTARIUS

1855.0 $\alpha = 18^h 7^m$ $\delta = -18°15'$

Enlarged 4.1 times, Scale $\begin{cases} 1 \text{ in.} = 16'.0 \\ 1 \text{ cm} = 6'.3 \end{cases}$

observations there has sometimes been a suspicion that I could see an actual object at this point. An observation of this kind, however, requires both good definition and good transparency. A little unsteadiness of the air blurs the light of the many near-by stars into a mistiness of the field, and a want of transparency cuts off any feebly luminous object and readily defeats any effort to see it. On the night of July 27 of the present year, the conditions were very favorable, both for transparency and for steadiness. Under these conditions the hole or spot was examined very carefully with the 40-inch telescope. With its following edge cutting across the middle of the field, which is some three times smaller than the spot, it was quite distinctly seen that the preceding half of the field, in which there were no stars, was very feebly luminous, while the following side showed a rich, dark sky with the few small stars on it. From the view, one would not question for a moment that a real object—dusky looking, but very feebly brighter than the sky—occupies the place of the spot. It would appear, therefore, that the object may be not a vacancy among the stars, but a more or less opaque body.

The photographs with a portrait lens show this object black against a luminous sky. The explanation of this apparent anomaly is that the sky about it is filled with innumerable small stars, both visible and invisible, with perhaps some nebulosity. The effect of these upon the plate is to counterbalance the feeble light from the matter forming the hole, and thus to produce by contrast the appearance of a vacant spot; or in other words, if the object were placed on the ordinary dark sky away from the Milky Way, it would be seen and photographed as a luminous spot, sharply defined on one side and diffused on the other; or, similar to a sun-spot, it is black only by contrast with its brighter surroundings. Perhaps this can be made clearer when we remember that the scale of the portrait lens is relatively very small, and that the stars crowd together here so thickly that their images on the photograph almost coalesce into a complete bright sheet, or continuous background, on which the spot stands out strongly. This of course accentuates the definiteness of the hole and the contrast it makes with the sky. If a sufficiently long exposure were

made with a long-focus instrument like the 40-inch telescope, to show the faintest stars on the portrait lens plate, the hole would not be recognizable except from the want of stars at that point. This is essentially what happens, only it is more marked, in the visual observations of this object with the large telescope.

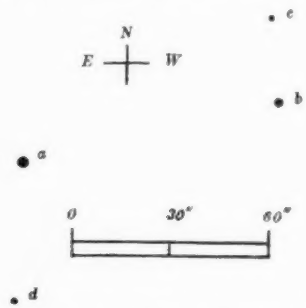


FIG. 1.—Chart of stars in black spot 1855.0: $\alpha=18^h7^m$; $\delta=-18°15'$.

At the suggestion of Professor J. C. Kapteyn, I have measured the position of the small star in the hole with respect to stars outside of it, as there is a possibility that the star is on this side of the general background. I have also measured the positions of several faint stars quite near with respect to it. See diagram, Fig 1.

THE CENTRAL STAR AND AN $8\frac{1}{2}$ MAGNITUDE STAR FOLLOWING

(= *B.D.* $-18°4871$ [8^m4])

Date		$\Delta\alpha \cos\delta$	$\Delta\delta$
1913.504	July 3	$-301''.91$	$+0'\ 40''.3$
.513	6	-301.57	$+\ \ 40.3$
.529	12	-301.65	$+\ \ 40.3$
1913.515		-301.71	$+0\ 40.3$

$$\therefore\ \Delta\alpha=-0^m21^s.18.$$

On July 6, 1913, the $\Delta\alpha$ was also determined by transits:

$$\Delta\alpha=-0^m21^s.10 \text{ (8 tr.)}.$$

On this last date also, I measured by transits the position of the small star relative to a 9th-magnitude star preceding it, = *B.D.* $-18°4853$ (9^m2) = Bordeaux A.G.C. *5313*.

1913 July 6 $\Delta\alpha$ (small star -9^m star) $+1^m7^s.11$ (8 tr.)
$\Delta\delta$ $+2'26''.4$ (4).

These last measures give the position of the small star (which we shall call *a*):

$$1913.0 \qquad \alpha=18^h10^m28^s.82 \qquad \delta=-18°15'27''.3.$$

Singularly enough the star 4853 is in the *Bordeaux Catalogue* (No. 5313), while 4871, a much brighter star, is not.

Following are the measures of the smaller stars:

a and *b*

Date		P.A.	Dist.	Mags.
1911.391	May 23	285°.25	80.67	11.0 13.0
.424	June 4	282.41	80.34	12.2 13.9
.429	6	282.32	80.37	
.462	18	282.14	80.59	
1913.504	July 3	282.30	80.33	
1911.842		282.88	80.46	11.9 13.6

b and *c*

1911.391	May 23	3°.62	25″.76	15.5
.424	June 4	3.56	25.38	16
.462	18	5.73	25.01	15
1911.426		4.30	25.38	15.5

a and *d*

1913.570	July 27	176°.13	42″.14	15½
.576	29	175.83	42.43	16½
1913.573		175.98	42.28	16

On June 18, 1911, *d* was estimated to be of the 16th magnitude. It is very faint and difficult to measure, and is shown very feebly on the original photograph. The star *c* is difficult to measure unless the seeing is good.

The plate also shows a narrow black marking some 20′ following the one under discussion. This is very black in its north end, and is doubtless of a similar nature to the larger one.

Another black spot, which I came across some thirty-odd years ago,[1] is perhaps still more remarkable because it is even smaller (5′ ± in diameter). It is found in a dense part of the Milky Way, in about the position:

$$1875.0 \qquad \alpha = 17^{h}55^{m}.1 \qquad \delta = -27°59'.$$

[1] *Astronomische Nachrichten*, **108**, 369, 1884.

It is a very striking object in a 5-inch telescope, where it looks like a drop of ink on the luminous sky. The photographs show it black, but with some faint stars in it. On the preceding border is a bright orange-colored star (perhaps *Argentine General Catalogue*, 24531 [$8\frac{1}{2}$ mag.])

$$1875.0 \qquad \alpha=17^h55^m32^s.04 \qquad \delta=-27°53'19''.8.$$

Near the hole, and preceding it, is a cluster of small stars.

There are many other small black spots in the Milky Way (which are shown on my photographs) in which I am interested, and of which it is hoped soon to make a catalogue. A considerable number of very small ones are found in the great star cloud whose center is in

$$1855.0 \qquad \alpha=18^h46^m \qquad \delta=-7\frac{1}{2}°.$$

With respect to the question of obscuration of light in space, there is one other object which strikingly shows this effect. In the east side of the well known nebulous stream that runs southward from ζ *Orionis* is a very conspicuous black notch which is very sharply defined. This striking feature is well shown on a photograph by Dr. Isaac Roberts which was printed in the *Astrophysical Journal*, **17**, Plate IV. In the text of his article ("Herschel's Nebulous Regions") at p. 74, Dr. Roberts refers to the dark spot as an "embayment," and dismisses it with the following statement: "To the south of ζ is a stream of nebulosity, 54′ of arc in length, with an embayment free from nebulosity dividing it in halves."

This object has not received the attention it deserves. It seems to be looked upon as a rift or hole in the nebulosity, as implied in the quotation from Dr. Roberts' paper. I have made numerous photographs of it, and in the past winter gave a long exposure with the expressed purpose of showing more definitely the true form of the object. This last photograph on February 7, 1913, with an exposure of 4^h33^m, shows the nebulosity better than I have seen it before. Instead of an indentation, the almost complete outline of a dark object is shown projected against the bright nebulosity. The west side of it is very definite and sharp, while the eastern limit is scarcely discernible, and is entirely lost in the enlargement. The best description I can give of it is to

present the photograph of the object itself for inspection (Plate XX, Fig. 1). A glance at the original would show that this is not a perforation in the nebula. It is clearly a dark body projected against, and breaking the continuity of, the brighter nebulosity. Possibly this is a portion of the nebula itself nearer to us, but dark and opaque, that cuts out the light from the rest of the nebula against which it is projected.

On the night of November 4, 1913, with good conditions of seeing and fair transparency, I examined this object with the 40-inch telescope and a power of 460. The position was carefully located with the aid of the photograph. The outlines of the spot—so sharp and clear in photographs of this region—could not be made out with any definiteness. The view showed that the spot is certainly not clear sky, for the field was dull, apparently indicating the presence of some material substance at this point. To me the observation would confirm the supposition of an obscuring medium at this point.

The position of this remarkable object from the *B.D.* charts is

$$1855.0 \qquad \alpha = 5^h 33^m\!.6 \qquad \delta = -2^\circ 35'.$$

YERKES OBSERVATORY
November 15, 1913

MINOR CONTRIBUTIONS AND NOTES

THE VARIABLE RADIAL VELOCITY OF *113 α PISCIUM*

The variable velocity of this double star ($\alpha = 1^h 57^m$; $\delta = +2° 17'$; mags. 5.2 and 4.3; type A2p) was established immediately after the second and third plates had been obtained. The possibility of misleading influence due to the spectrum of the fainter star led the director to suggest separating the two stars on the slit of the spectrograph. (The present distance of the components is about 2″.4, the angle 318°.) This was readily done on a night of average "seeing" by removing the correcting lens, which causes the blue images to coalesce, and by guiding with the stars in focus for visual light. This involves shortening the focal setting of the spectrograph by 34 mm and lengthening the exposure time to about 75^m for the brighter and about 100^m for the fainter star.

The first pair of plates of the separated images was obtained on October 9, 1908, after a long and a short exposure had been made in the usual way to see if the presence of the fainter spectrum could

TABLE I

OBSERVATIONS OF THE BLENDED SPECTRUM

Plate	Date	Julian Day	Taken by	Velocity	No. of Lines	Quality
				km		
IB 1274.......	1907 Dec. 6	2417916.551	F	− 5.0	11	v.g.
1695.......	1908 Aug. 24	8178.855	L	+15.6	11	g.
1703.......	Aug. 25	8179.780	L, B	+24.0	10	f.
1713.......	Aug. 28	8182.858	L	+ 2.0	9	g.
1721.......	Sept. 7	8192.828	L	+ 6.2	8	f.
1729.......	Sept. 8	8193.730	L	+19.0	9	v.g.
1730.......	Sept. 8	8193.765	L, B	+ 2.4	10	v.g.
1740.......	Sept. 18	8203.819	L	+12.9	9	f.
1757.......	Sept. 25	8210.793	B, L	+ 6.1	6	g.
1768.......	Oct. 2	8217.826	L	+ 4.1	9	v.g.
1775.......	Oct. 5	8220.780	L, B	+ 4.3	4	g.
1782.......	Oct. 9	8224.659	L	+ 8.5	13	v.g.
1783.......	Oct. 9	8224.682	L	+ 8.3	7	g.

In column 4, "Observer," B = Barrett; F = Frost; L = Lee. Mr. Sullivan, as usual, assisted in observing.

be detected in this manner. All later observations have been made upon the separated stars. Only three pairs of plates were obtained that season, and to our surprise, these failed to show any appreciable variation of velocity in either component. Additional plates secured during the past year prove that each star is binary. Meanwhile Campbell in *Lick Observatory Bulletin* **6**, 142, 1911, announced the variable velocity from observations of the blended light. Reference to No. 1061 in Burnham's *General Catalogue*, shows that the changes in orbital velocity of the two stars are inappreciable for the period covered by the spectrographic observations.

On Plates 1721 and 1729 violet components were measured which gave velocities of −6 and −12 km from 4 and 6 lines, respectively. The decrease in velocity from No. 1729 to No. 1730 may be caused by the line complexity in the former. The long and short exposure plates 1782 and 1783 show no differences in spectrum and the close agreement of the velocities derived indicates a superposition of the component lines in this particular phase.

TABLE II

OBSERVATIONS OF THE BRIGHTER STAR

Plate	Date	Julian Day	Taken by	Velocity	No. of Lines	Quality
				km		
IB 1784	1908 Oct. 9	2418224.722	L	+0.1	6	g.
				−1.3	7	
1811	Oct. 30	8245.876	L	+2.3	6	g.
				+3.3	3	
1820	Nov. 2	8248.783	L, B	+6.3	5	g.
				+6.1	4	
3175	1912 Nov. 29	9736.625	L	−0.3	7	v.g.
				−3.0	9	
3217	Dec. 27	9764.674	L	+17.4	5	v.g.
				+17.2	5	
3256	1913 Jan. 24	9792.502	L	−3.3	8	v.g.
				+0.3	5	
3266	Feb. 3	9802.515	L	+25.3	8	g.
				+28.7	5	

The second measure given for each plate is a duplicate made recently as a check, and the means may be taken without weighting. The region from H_γ to H_β was used. No real differences in the two spectra have been observed.

TABLE III

OBSERVATIONS OF THE FAINTER STAR

Plate	Date	Julian Day	Taken by	Velocity	No. of Lines	Quality
				km		
IB 1785.......	1908 Oct. 9	2418224.792	L	+ 4.0	7	g.
				+ 4.0	5	
1810.......	Oct. 30	8245.809	L	− 1.8	6	g.
				+ 1.0	5	
1819.......	Nov. 2	8248.712	L	+ 5.8	5	g.
				+ 5.4	6	
3176.......	1912 Nov. 29	9736.699	L	+19.7	7	v.g.
				+22.9	5	
3216.......	Dec. 27	9764.603	L	+ 5.7	8	v.g.
				+ 3.9	3	
3257.......	1913 Jan. 24	9792.572	L	+20.4	6	v.g.
				+19.7	5	
3267.......	Feb. 3	9802.586	L	+ 4.1	7	g.
				− 1.6	5	

The average exposure time for the brighter star is 75^{m}; for the fainter 104^{m}, or 39 per cent longer. Estimates of the relative strengths of exposure of the plates, taken pair by pair, show that the plates of the fainter star are on an average about 30 per cent stronger than those of the brighter star. That is to say, the two spectra are of about the same magnitude photographically while differing by 0.9 of a magnitude visually. This would hardly be expected, considering the practical identity of the spectra. The data for the separate stars are too meager to justify a statement about the period. The chance is more than even that higher dispersion will show components for either or both of these stars and two or three prisms should be used in further investigations of them.

OLIVER J. LEE

YERKES OBSERVATORY
October 1913

ON SLIPHER'S SPECTROGRAMS OF THE MAJOR PLANETS

In *Nature* (**79**, 42, 1908) Professor P. Lowell has published a table of spectra of the major planets, composed by V. M. Slipher on the basis of his spectrograms obtained at the Lowell Observatory.

Two botanists—Beijerinck and Timirjasev—showed almost

at the same time, that among the dark bands in the spectra of *Uranus* and *Neptune* there is one (between B and C), which coincides with the most characteristic band of the absorption spectrum of chlorophyl.

In *Bulletin No. 42* of the Lowell Observatory Slipher had published a longer article on the spectra of the major planets. He indicated here that between B and C at λ 6670 (mean) there is also "a very broad and very weak" band in the spectra of *Jupiter* and *Saturn* (p. 237).

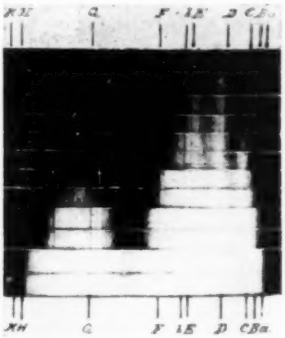


Fig. 1

Fig. 2

Slipher's spectrograms were taken upon plates sensitized with dicyanin, pinacyanol, and pinaverdol. Yet photographic plates sensitized with dyes have not ordinarily a uniform sensitiveness in all parts of the spectrum; their "sensitiveness-spectrum" depends upon the absorption spectrum of the dyes employed.

I have investigated how far the sensitiveness of photographic plates is in fact uniform after sensitizing with pinacyanol, pinaverdol, dicyanin, homocol (also employed by Slipher), and their combinations. I have found that neither any single dye of those named, nor their combination, gives a plate of perfectly uniform sensitiveness.

The sensitiveness-spectrum of a plate, sensitized after Slipher's method (with washing in water), may be seen in Fig. 1. This figure is composed of a series of spectrograms of the sun taken with a gradually increasing exposure. On the lowest spectrogram,

taken with a very long exposure ("over-exposed"), all the bands of the sensitiveness-spectrum have disappeared.

In Fig. 2 we see the less refrangible half of the spectra only. This plate was sensitized like those mentioned above, but the dyes were "diluted with equal parts of water and alcohol," and "rinsed in alcohol" according to the other modification of Slipher's method. The three upper spectra are those of the Welsbach-light, the lower—taken at the same time—of the sun. *The dark band between* B *and* C *is here very strong.*

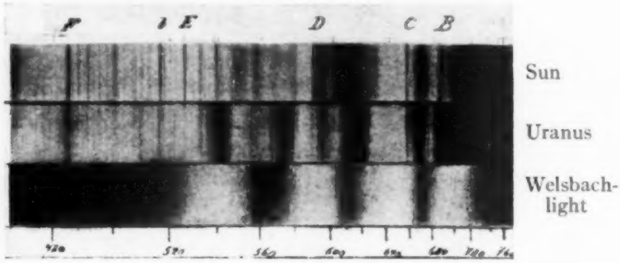


FIG. 3

It may be thought that I simply have not succeeded in obtaining plates of so uniform a sensitiveness as did Slipher. But on Slipher's own spectrograms of *Mars*, and especially of the moon, reproduced in "The Spectrum of *Mars*" (*Astrophysical Journal*, **28**, 1908, Plate XXXVI, Figs. 1 and 2), these minima of sensitiveness are quite clearly visible.

To show these dark bands strongly the dispersive power of the prism employed must be low and the exposure short. Both these conditions were present in the case of Slipher's spectrogram of *Uranus*.

The comparison of Slipher's spectrum of *Uranus* with my spectrograms of the sun and of the Welsbach-light (Fig. 3) makes it seem very probable that in Slipher's case we have a combination of the true spectrum of *Uranus* with the sensitiveness-spectrum of the sensitized plate.

The actual existence in the spectrum of *Uranus* of the band between B and C is therefore subject to doubt until it is confirmed by other methods.

Consequently there is at present no solid ground for the comparison of the spectrum of *Uranus* with the spectrum of chlorophyl, the presence of which in the major planets is very improbable.

V. Arcichovskij

Novočerkassk
June 2, 1913

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An International Review of Spectroscopy and Astronomical Physics

EDITED BY

GEORGE E. HALE
Mount Wilson Solar Observatory of the Carnegie Institution of Washington

EDWIN B. FROST
Yerkes Observatory of the University of Chicago

HENRY G. GALE
Ryerson Physical Laboratory of the University of Chicago

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